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A DESIGN FOR AN ELECTRIC AUTOMOBILE VEHICLE.

By CHARLES T. CHILD.

THE immense popularity attained abroad within the last two years by all sorts of motor-driven vehicles must soon find a parallel in this country. Unfortunately automobiles have been, so far, playthings of the rich rather than instruments of pleasure or profit for the general public, and a French contemporary laments that to own an automobile one must not only have the wealth of a Crœsus to order it, but also the patience of a Job to wait for its delivery. The sport of "automobilizing" must inevitably become popular when the price of self-propelled vehicles is brought within the reach of ordinary people, but to-day the person of average means who wishes to own an automobile must either build it for himself or wait the coming of the day when the prices of such machines descend to a reasonable level.

The designs that form the subject matter of this article are for a type of motor vehicle that can be constructed by an amateur of fair skill having at his disposal the resources of a small machine shop. So far as possible, the design has been simplified so that there is little of the work that cannot be done on a foot lathe and with the small tools usually at the disposal of the amateur in mechanical matters. The designs show an electrically propelled vehicle for one person, having a maximum speed of about 12 miles per hour and a capacity for about 20 miles run on fairly level good roads with one charge of the battery. It consists of two drop frame bicycles connected together and driven by two small electric motors. Its cost, to a person doing the greater part of the work upon it himself, will be found to be comparatively small, while the work itself requires no skill not possessed by an amateur of ordinary ingenuity.

Referring to Figs. 1 and 2, which show respectively a side and rear elevation of the complete vehicle, it is seen that a frame, *A*, suspended from the rear of the machine, supports the batteries, and that two motors are used. This construction is necessary on account of the mechanical difficulty, when only one motor is used, of connecting the driving wheels so that one will run ahead of the other in rounding curves. This difficulty is considerably greater than that of making two motors from the same patterns.

Fig. 3 shows a perspective view of the frame of the machine without wheels, and with only one of the motors in position. The bicycles of which it is compos-

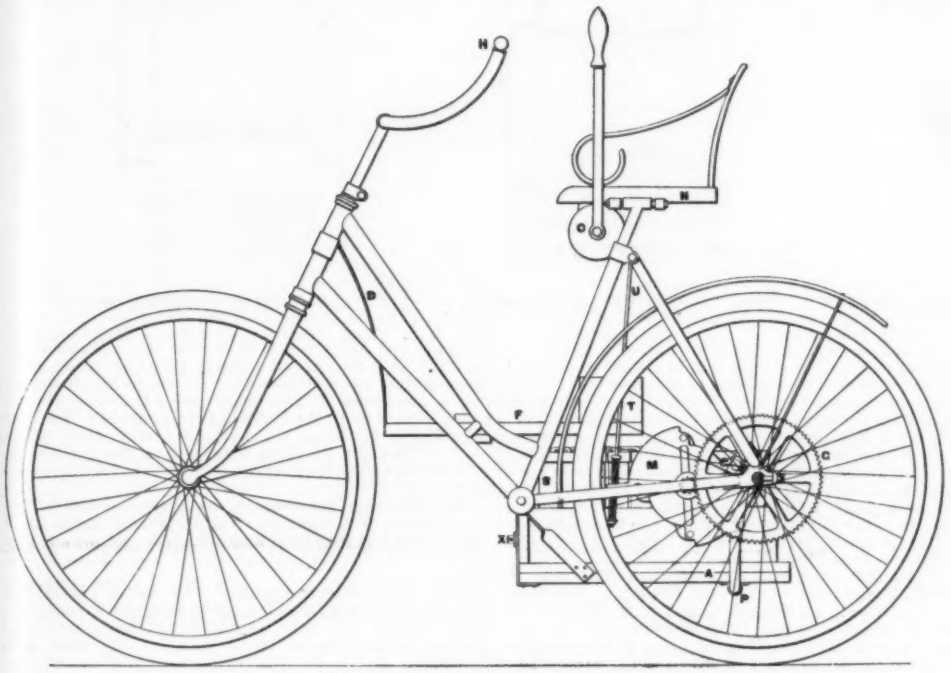


FIG. 1.—SIDE ELEVATION OF COMPLETED VEHICLE.

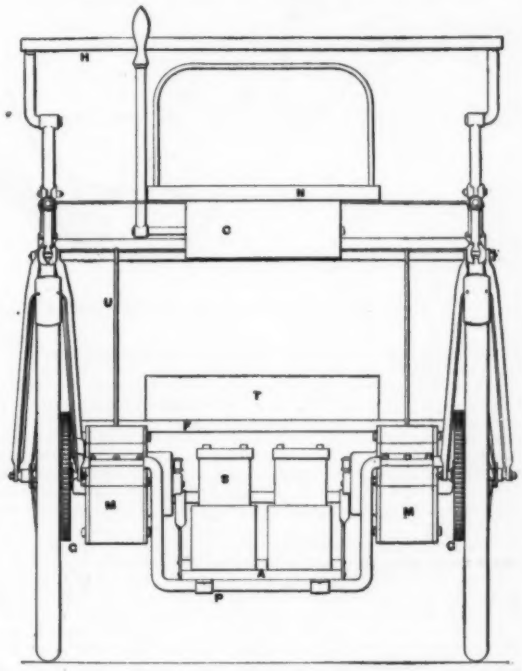


FIG. 2.—REAR ELEVATION.

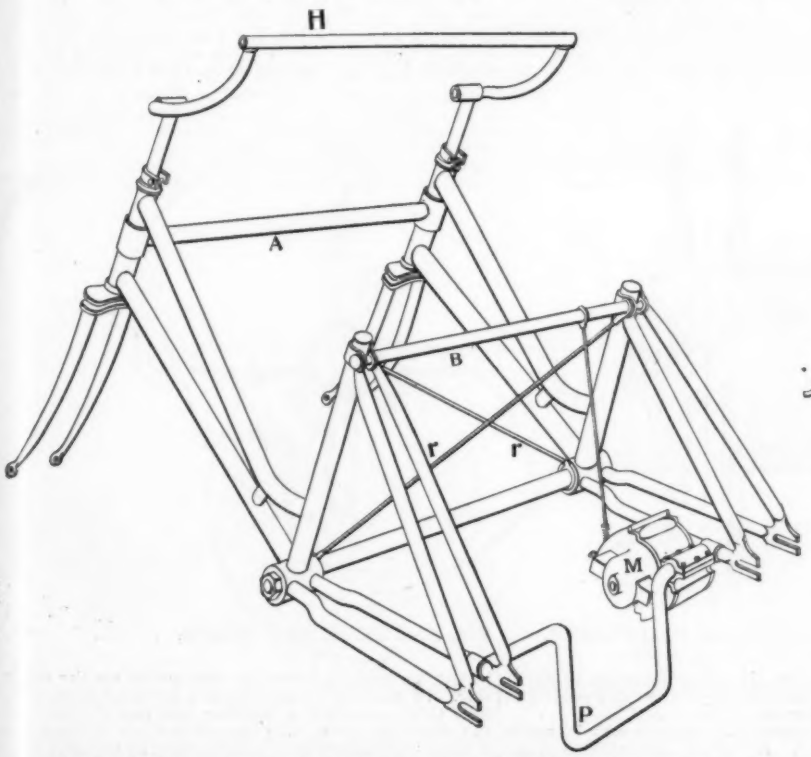


FIG. 3.—PERSPECTIVE VIEW OF FRAMEWORK, SHOWING ONE MOTOR IN POSITION.

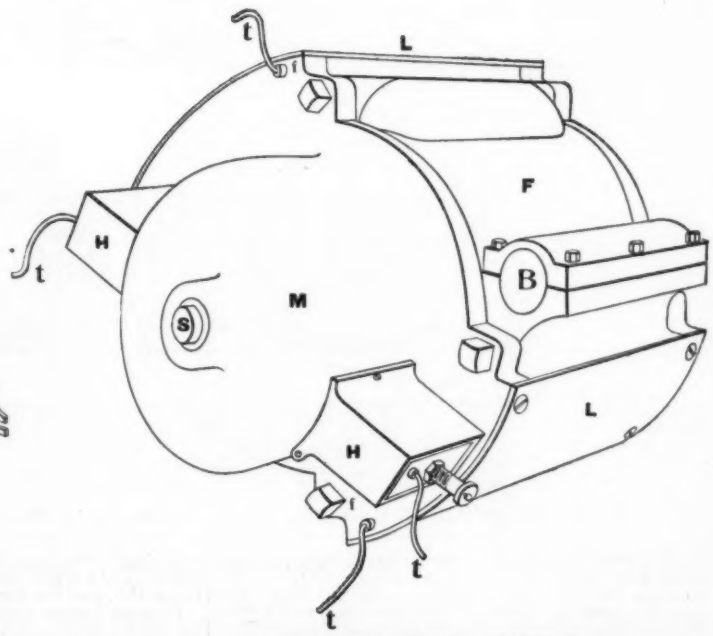


FIG. 4.—MOTOR COMPLETE, SHOWING COMMUTATOR END.

ed should be exactly alike and of substantial make, not too light. They are stripped of pedals, sprockets, chains, saddles, and handle bars and are connected, as shown in the figure, by four pieces of tubing and two small tension rods, *r*, *r*, so that the centers of the frames are not less than 33 inches apart. The tube, *A* (Fig. 3), may be of 1¼ inch bicycle tubing, about 24 to 28 gage, and may be fastened to the two forward bearing tubes of the bicycles in any convenient way, but best by brazing to collars as shown. The cross piece, *B*, is a stout piece of steel tubing, about ⅛ inch thick, such as a piece of ¾ inch steam pipe, having a piece of steel rod brazed into each end, on which are cut threads to receive the nuts as shown. This piece of tubing replaces the bolts that tighten the grip of the upright tubes of the bicycles upon the saddle posts. The tube, *C*, is a piece of gas pipe of a size to fit in the pedal-bearing seats, threaded externally and carrying, on the parts

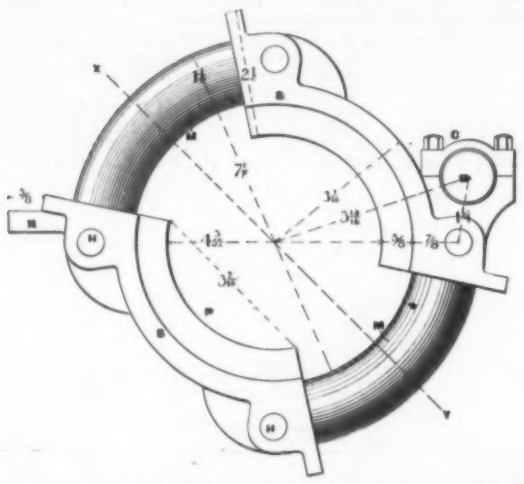


FIG. 5.—END ELEVATION OF MOTOR FIELD MAGNETS.

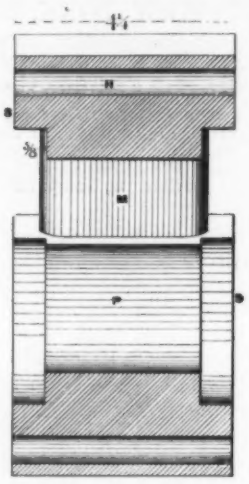


FIG. 6.—VERTICAL SECTION.

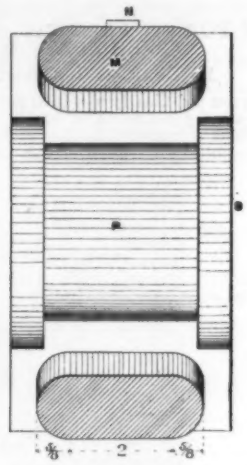


FIG. 7.—SECTION AT X Y.

abutting against the inner surfaces of the pedal bearings, flanges which are brazed to the rods, *r*, *r*. These rods are of ¼ inch steel and are to be stretched as tight as possible. The bent tube, *P*, is brazed to collars surrounding the inner members of the rear forks and consists of a piece of ¾ inch (inside) steam pipe. The horizontal end parts form a bearing for the motors, and the middle part is depressed 9½ inches to receive the frame, *A* (Figs. 1 and 2), which holds the batteries. This horizontal lower part of the tube is 15 inches long in the clear.

The rods, *r*, *r*, give the middle of the frame a certain amount of rigidity, but it is advisable, and indeed necessary, to allow the frame to bend somewhat, so that it will conform to uneven surfaces of the road. For this reason the tube, *A*, should not be too stiff.

Referring to Fig. 1, *F* is a flooring of ¾ inch board, supported by wooden cleats driven between the parts of the tubular frame as shown. A sheet iron dashboard, *D*, is attached to the floor and the forward cross rod. The battery frame, *A*, is supported from the tube, *C* (Fig. 3), by light wrought iron straps and rests upon the lower horizontal part of the tube, *P*, to which it is fastened by straps as shown. At the rear of the floor, *F*, is a small tool box, *T*.

The two handle bars are fashioned into the shapes

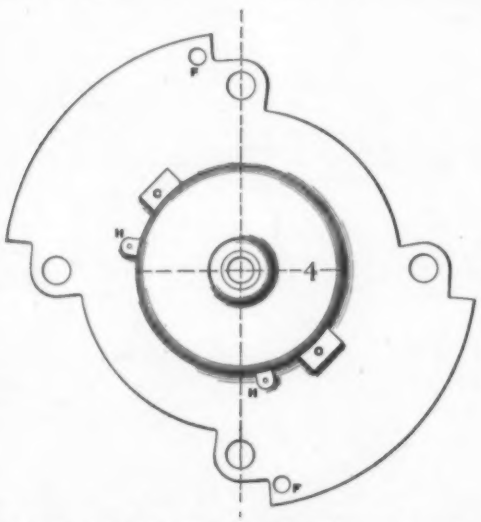
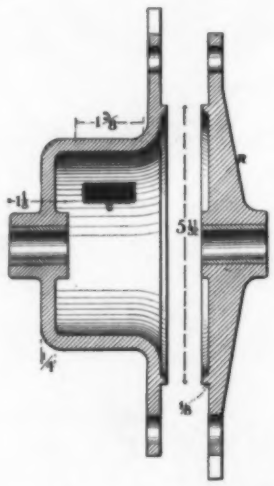


FIG. 8.—COMMUTATOR END PLATE.



FIGS. 9 AND 10.—SECTION OF END PLATES.

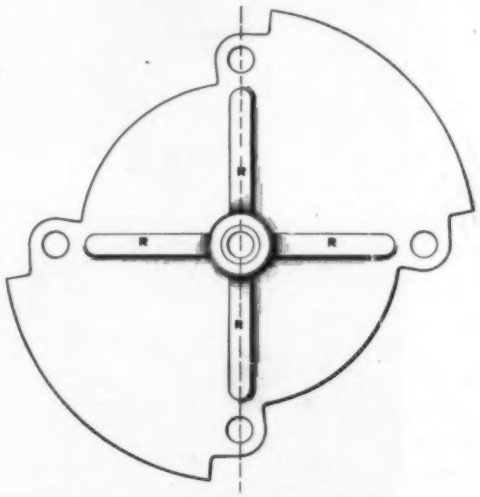


FIG. 11.—PINION END PLATE.

shown, and connected by the tube, *H*, pivoting into them, so that it may be grasped at any part and used to turn the two front wheels simultaneously. The seat is swung from light steel straps attached to the saddle posts in the way clearly shown in the figures.

A stronger vehicle may be made from two diamond-frame bicycles, but it has the objection that the rider must climb over some part of the frame or connecting parts to get to his seat, and in case of accident cannot so readily jump out. While this method of constructing the frame of the vehicle from bicycles is a good and cheap one, resulting in a very strong vehicle of light weight, the motors and batteries described below may be adapted to other forms of vehicles with great success. It should be remembered, however, that if a vehicle having wheels of larger diameter is used, the gear reduction, which is 10 to 1 in this design, must be made correspondingly greater, or the motors will burn

This suspension is somewhat like that of a street car motor, and the springs on the rod, *U*, soften the shocks due to the inertia of the motors in running the vehicle over obstructions in the road. The motors are shown in detail in Figs. 4 to 15. They are of the iron-clad type, completely inclosed to keep out dust and moisture, and can develop a maximum output of 0·6 horse power each. The frame of the motor consists of an iron casting, shown in Figs. 5, 6, and 7, closed by the end-plates shown in Figs. 8 to 11. Fig. 4 shows the complete motor. *B* is the bearing by which the motor is supported from the tube, *P*, of Figs. 1 to 3. It extends across the cast iron part of the field and is covered by a lid, *C* (Fig. 5), attached by cap screws. The hole, *B*, should be bushed with brass and the lid, *C*, provided with an oil hole. In Figs. 5, 6, and 7, *H H* are holes for the reception of ½ inch bolts which secure the end-plates in place. The winding surfaces, *M M*, are curved in two directions as shown, the cross section of the cores being composed of a rectangle and two semicircles. In finishing the casting the first operation is to bore the holes, *H H*. Then the surfaces, *P P*, are bored out to a diameter of $4\frac{3}{8}$ inches and the bearing surfaces, *S S*, against which the end-plates abut, finished off. The illustrations so clearly show the form and dimensions of the field magnets that any further description is unnecessary. It is not necessary to finish any part of the field casting except the inner polar surfaces, *P P*, and the bearing surfaces, *S S*.

Patterns for casting the field magnets may be easily made by any amateur. It will be advisable to make them out of a blank made up of a number of white pine rings about 9¼ inches diameter outside and 3⅛ inches diameter inside by about 1 inch thick, glued together with the grain crossing. From this cylinder-shaped blank the field pattern can be easily carved out, the reason for using the crossed grain structure being that the pattern is not so apt to warp in the sand. As two castings will be required, this is important. After allowing for shrinkage in casting, about ⅛ inch of metal should be left to be machined out in the armature space and on the end bearing surfaces where the end plates are fitted.

It is well to have at least three castings made, as one is apt to be broken or prove defective, and it is quite necessary to have the two motor frames cast from the same run of metal to insure uniformity in their magnetic qualities. Do not have the castings made at a stove foundry, as the iron used in stoves is apt to give very undesirable performance when made up into a motor. It is also apt to be hard and difficult to work. The best place to get the castings made is at some foundry where dynamo castings are regularly made. Failing this, the best results are usually had from a foundry in connection with some machine works where a quality of iron is used that will work easily. There is a large element of luck about castings, and it is urgently recommended that, as these will cost very little, at least three, and better four, be made, so as to insure getting good ones.

End plates of brass or bronze, shown in Figs. 8 to 11, close the ends of the motor. The plate at the commutator end (Figs. 8 and 9) carries the tubular bearings, *C C*, for the brush holders and the studs, *H H*, upon which the brush-holder boxes, to be described below, are hinged. The bearings for the shaft should be babbitted or bushed with brass, probably the best plan being to wrap the armature with thin paper until it just fits the field bore, put on the end plates, and babbitt the bearings, as this will secure the alignment of the machine.

The only finishing required by these end plates is at the surfaces, *S S*, where they abut against the finished surfaces of the iron field magnet. At the pinion end of the shaft the end plate is ribbed (*R R*, Figs. 10 and 11).

After the fields are wound, the brass plates, *L L* (Fig. 4), which may be of $\frac{3}{32}$ or ⅛ inch sheet brass, are bent around the field and fastened with screws as shown, their purpose being to keep out dust and moisture. In the end plates are secured the rubber or fiber bushings, *f f*, through which are brought out the ends of the field coil, *t t*.

Fig. 4 shows the brush-holder boxes in place on the end plate, and Figs. 12 and 13 show them in detail. Referring to the latter, the four-sided box, *H*, is of brass or cast iron, 1/16 inch thick, and is hinged to the studs (*H*, Fig. 8), as shown, so that the whole box may be thrown back by loosening the screw on the other side. In the top of the box is a piece of slate, *S*, $\frac{3}{16}$ inch thick, carrying a bushing and nut, *n*, threaded to receive the screw, *a*. Through the axis of this plays a small rod carrying a coiled spring at its inner end, which presses against the carbon brush. In Fig. 13, *p* represents a section of the projection of the end plate of the motor. In the tubulure shown at *C C* (Figs. 8 and 9) is mounted the bearing for the brush. The carbon brush is 1¾ inches long, ⅞ inch wide (measured parallel to the shaft), and ⅜ inch thick. A square-cornered tube of sheet copper, about $\frac{1}{16}$ inch thick, shown at *K*, Fig. 13, is made to fit the brush loosely. The tubulure in the end plate casting is filed out to about $\frac{1}{16}$ inch larger in each direction than this copper tube, and the space between the two is packed with mica, *M*, cemented together with stiff shellac. The whole is then heated on a stove to about 400 de-

grees (just sufficient to make a pine chip smoke) for an hour or two, thus firmly cementing the tube, *K*, in place by an insulating bushing of "micanite." Connection is made with a wing left on the copper tube, the terminal wire being brought out through the hole, *z*, in the slate. This slate is cemented to its place in the box casting either with white lead or bicycle tire cement, the former being much better.

Shafts for the motors are made of ⅜ inch machinery steel, each being 9½ inches long. Fig. 14 clearly shows their dimensions. The core of the armature is made of 4-inch disks of good armature iron, which may be

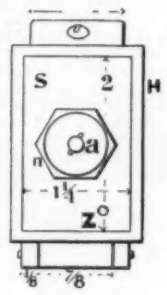


FIG. 12.—PLAN OF BRUSH HOLDER.

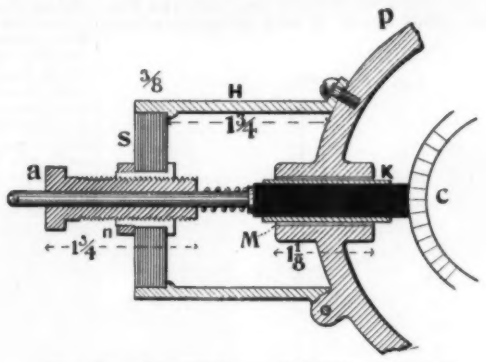


FIG. 13.—SECTION OF BRUSH HOLDER.

bought with the ⅝ inch hole punched in the center. End pieces, *H*, of ⅛ inch steel plate are provided, and disks of about No. 24 gage are used, each armature requiring about 125 disks. These may be lightly japanned on one side before assembling, but this is not absolutely necessary. Twenty-four slots, as shown in detail in Fig. 15, are milled in each armature core, the slots being a trifle less than ¾ inch deep and $\frac{1}{16}$ inch wide. The armature must finish to 4 inches diameter or, if smaller, the bore of the field casting must be reduced until the clearance is $\frac{1}{32}$ inch on each side. The commutators are 2½ inches diameter, 1 inch face, not more than 1⅛ inches long along the shaft, ⅝ bore, 24 segments, and are far best bought ready made, this

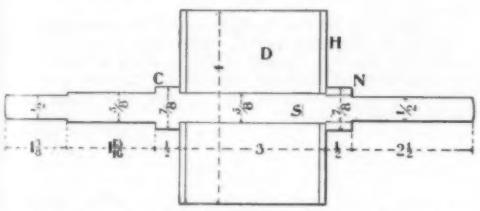


FIG. 14.—ARMATURE CORE AND SHAFT.

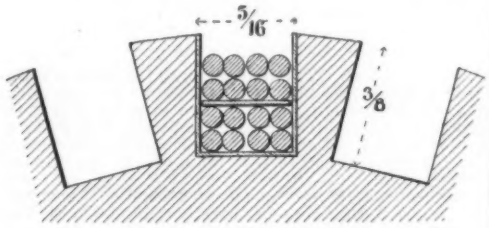


FIG. 15.—DETAILS OF ARMATURE SLOTS.

being a commercial size. They will cost only a few dollars. A feather, not shown in the illustrations, is provided on the shaft to hold the commutator from turning. The wires soldered in it hold it sufficiently endwise.

The winding of the fields is very simple. Each of the winding spaces, *M M*, Fig. 5, is wound with 174 turns of No. 12 (B. & S. gage) single cotton-covered copper wire, which will arrange itself in six layers. The inside layers will be close together, while those on the outside, owing to the curvature of the cores, will be somewhat spread. This makes no difference. Each layer should be painted with some good waterproof varnish, such as P. & B., as it is wound. Before winding the cores, *M M*, the end surfaces, against which the windings abut, should be insulated with a layer of cotton cloth stuck on with the varnish. About 230 feet of the wire will be required for each coil, and this length should be cut off and wound up on a spool small enough to pass through the central opening of the casting before the winding is begun. The two coils on each frame should be wound with the turns circling the iron the same way, as looked at from the side carrying the bearing, *B*, for example, and the inner end of one coil must be connected to the outer end of the other, the connection being made by a piece of wire surrounded with a rubber tube and laid in the recess of the casting between the pole face and the end plate. The two remaining ends are brought out through the bushings, *F F*, in the end plate (Fig. 8).

To be sure that the winding is correctly connected, pass current from two or three cells of battery, or through a few incandescent lamps, through the coils. The two polar faces should show opposite magnetism and should be more highly magnetized than any other part of the field casting. If they seem to be weakly magnetized, and there is evidence of strong magnetic poles under the windings, the coils are connected together in the wrong way and the connection must be altered. The two fields (of the two motors) should be so connected that a current circulating in the same way on each magnetizes them similarly.

The armature core is insulated with troughs of oiled paper about $\frac{1}{100}$ inch thick laid in the slots, as shown in Fig. 15, and the ends, *H*, Fig. 14, are covered with cotton cloth attached with the insulating varnish, the hub, *C*, and nut, *N* (Fig. 14), being also insulated the same way. No. 15 (B. & S. gage) wire is used on the armature, 16 wires per slot. The winding is of the simplest sort, there being eight turns per coil.

To wind the armature begin by numbering the slots consecutively from 1 to 24. Then make a small loop in the end of the wire to distinguish the starting end, and, starting at the commutator end of the armature and leaving about 6 inches of wire for the connection to the commutator, wind through slots 1 and 13, end over end of the armature core four turns, always going to the same side of the shaft at the ends. These four turns will neatly fill the bottom of the slot. Proceed to wind on four more turns over them, this time going to the opposite side of the shaft at the ends of the core, so that when the eight turns are in place there will be four wires on each side of the shaft at each end. All the visible wire should then be painted with the insulating varnish referred to above. When the eight turns are completed, cut off the wire, leaving an end about 6 inches long, and twist this and the starting end of the coil lightly together. The next coil begins in slot 14 and is wound through that slot and slot 2. The subjoined table gives the numbers of the slots for each coil in order:

Coil 1 in slots 1 and 13	Coil 7 in slots 7 and 19
Coil 2 in slots 14 and 2	Coil 8 in slots 20 and 8
Coil 3 in slots 3 and 15	Coil 9 in slots 9 and 21
Coil 4 in slots 16 and 4	Coil 10 in slots 22 and 10
Coil 5 in slots 5 and 17	Coil 11 in slots 11 and 23
Coil 6 in slots 18 and 6	Coil 12 in slots 24 and 12

All the slots are now filled with one set of eight wires in each, but only half the wire is on the armature. The next twelve coils go in on top of the first set, as follows:

Coil 13 in slots 13 and 1	Coil 19 in slots 19 and 7
Coil 14 in slots 2 and 14	Coil 20 in slots 8 and 20
Coil 15 in slots 15 and 3	Coil 21 in slots 21 and 9
Coil 16 in slots 4 and 16	Coil 22 in slots 10 and 22
Coil 17 in slots 17 and 5	Coil 23 in slots 23 and 11
Coil 18 in slots 6 and 18	Coil 24 in slots 12 and 24

As each coil has two ends, there are now forty-eight wires projecting at the commutator end, twisted together in pairs and one of each pair marked by the small loop mentioned above to indicate the beginning end of the coil. These are to be soldered into the slots in the tails of the commutator bars, two wires in each slot. Begin anywhere, taking the starting or looped end of one coil and the finishing or straight end of the next in regular order and solder them into the bar straight out in the line of the slot. This is repeated around the armature, each commutator bar receiving the inner end of one coil and the outer end of the next in regular order.

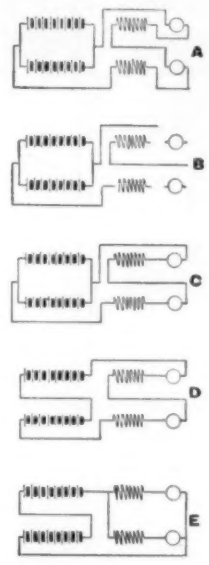


FIG. 16.—MOTOR CONNECTIONS.

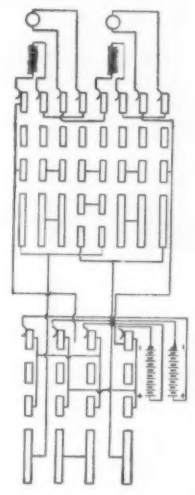


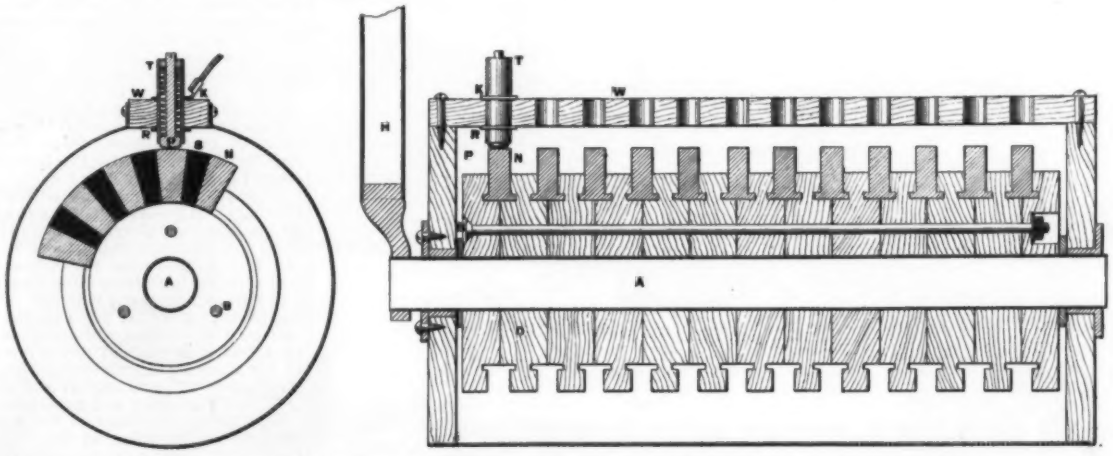
FIG. 17.—CONTROLLER CONNECTIONS.

Acid must not be used in soldering commutator connections. If the wires and slots are brightened with sand-paper, there will be no difficulty in making neat soldered joints with rosin as a flux. On the ends of the armature, where the various coils cross one another, pieces of thin muslin should be put between the coils, but care must be taken in the winding to build up neat "heads," or winding ends, and to arrange the wires as symmetrically as possible, otherwise the wires may bunch up to such an extent that the armature will not go in the machine or be so out of balance as to interfere with the operation of the motor at high speeds. A liberal use of the insulating varnish is recommended. After the first twelve coils are on they should be soaked in the varnish and the armature dried out at gentle heat in a cooking-stove oven or other convenient place. Insulation between the two coils in the same slot is not necessary, but a piece of oiled paper put in on top of the first coils will give a smoother surface to wind the second coils upon.

These motors are intended to work under a maximum pressure of about forty volts from the twenty cells of storage battery. Their constants are as follows for their maximum output: Volts at terminals, 40; amperes, 13·6; total watts, 544; losses in field and armature windings, 96 watts; efficiency, about 75 per cent.; speed, 2,000 R. P. M.; output, about 0·55 H. P.

It is needless to state that they are series motors.

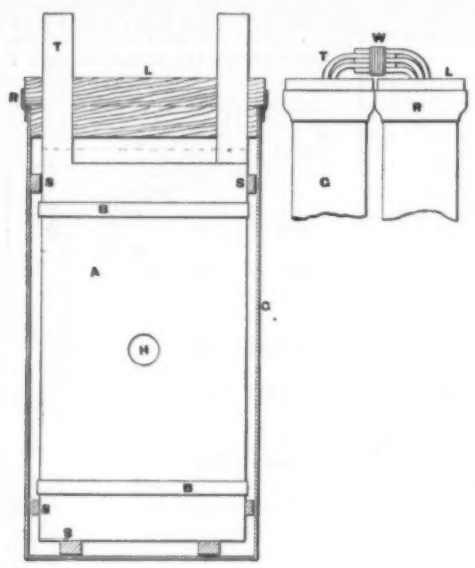
The controller, which couples the motors and the two sections of the battery in various combinations for various speeds, is attached to the under side of the seat, and is shown in Figs. 1 and 2, but to somewhat too small a scale. Before proceeding with a description of the controller itself it is well to examine the diagrams, Figs. 16 and 17, showing the connections made by the controller and the arrangement of its



FIGS. 18 AND 19.—TRANSVERSE AND LONGITUDINAL SECTIONS OF CONTROLLER.

contacts. Fig. 16 is a diagram of connections. The controller has five points, the connections shown at *A* being those for the reversing point. *B* shows the stop point, *C* the first speed ahead, where the two halves of the battery are in parallel and the motors in series. The next point gives the connections shown at *D*, the two halves of the battery in series supplying the motors also in series. For full speed the last point, *E*, shows the motors in parallel under the full tension of the battery.

In Fig. 17 the arrangement of the controller segments and contacts is diagrammatically shown. This diagram will be found useful in connecting up the controller points. In Figs. 18 and 19 the controller is shown in transverse and longitudinal sections. The



FIGS. 20 AND 21.—SECTION OF COMPLETE CELL AND CELL CONNECTIONS.

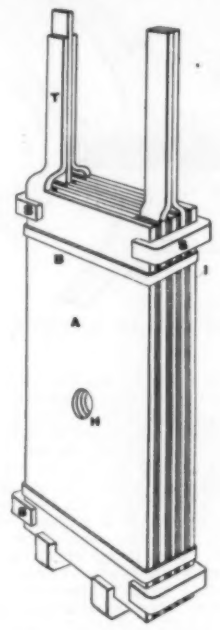


FIG. 22.—ELEMENT.

case is made of tin or sheet iron, bent around a diameter of 6 inches and fastened to a wooden bar, *W*, which carries the contact points. The heads of the case are of wood, about ½ inch thick, and carry bushings for the tube, *A*, the axis of the turning part. On this tube are mounted thirteen hard-wood disks, turned to the shape shown, each being about ⅞ inch thick and 4 inches in diameter. They are bound together endwise by three long bolts, *B B*, and clamp between their grooves the points, *N S*. These are of alternate conducting and non-conducting material, those shown at *N* being brass and those represented by *S* of slate or fiber or other hard insulating material not liable to take fire. There are twelve contact points, *P*, mounted, as very clearly shown in Fig. 18, in short brass tubes containing springs pressing them against the controller segments. The washers, *W* and *R*, are soldered to the tubes, *T T*, the outer washer carrying a connecter for the lead wire. The tubes, *T T*, should be about ⅝ inch inside diameter, and the heads, *P*, of the contact points should be rounded so that the controller segments will slip easily under them. Though not so shown in the illustration, it would be an excellent plan to lengthen the controller case about 2 inches and mount in the end of it a fuse block for the main circuit and some simple form of plug cut-out that the driver can carry away in his pocket when he dismounts, thus depriving the vehicle of motive power. None of the drawings show the cabling of the connections between motors, battery, and controller. This wiring should be neatly done in accordance with the diagram, Fig. 17, rubber covered and braided wire about No. 10 gage being used throughout. As this size of solid wire is rather stiff, it is better to use stranded wire. Whenever possible the bundles of wires should be bound tightly together with tape and painted with the insulating varnish.

The controller is mounted under the seat, so that the tubes, *T T*, are in a dry place and out of danger.

The batteries are of the Werner lead-zinc-cadmium type, twenty cells being carried in two boxes of ten cells each. The elements consist of five plates, three of them of sheet zinc and two of lead. The plates are cut out of ⅛ inch metal, 3½ by 6½ inches, a projection 3 inches long and ½ inch wide being left on the corner of each for a connecter. The lead plates are roughened with vertical striations by laying them on a piece of soft wood and hammering the teeth of a single cut file into them. Through the center of each plate is a ½ inch hole, *H*, Fig. 20, to allow a free circulation of the electrolyte. The plates are mounted as shown in Fig. 22, separating strips about ¼ inch wide by ⅛ inch thick being used. The best material for these is celluloid; but sheet rubber, such as is used for steam packing, will answer admirably. Each element is held together by six clamps or spacing pieces, *S S*, Figs. 20 and 22, sawed out of ¼ inch hard rubber, the two at the bottom serving as feet upon which the element stands in the cell. Rubber bands, *B B*, Figs. 20 and 22, assist in holding the element firmly in position. The corner strips are bent together, as shown in Fig. 22, and brought out through holes in the wooden cover of the cell, *L*, Fig. 20. For the cells the best material is hard rubber, but it may be difficult to find cells of the right size and shape. There are a number of ways of making good acid-proof cells, probably the best being to use wooden cells lined with very thin sheet lead, but this is heavy, and weight is a very important consideration in an automobile. Tin boxes may be made of the right size and shape and lined with thin sheet rubber, or better, $\frac{1}{32}$ inch soft rubber such as is used for

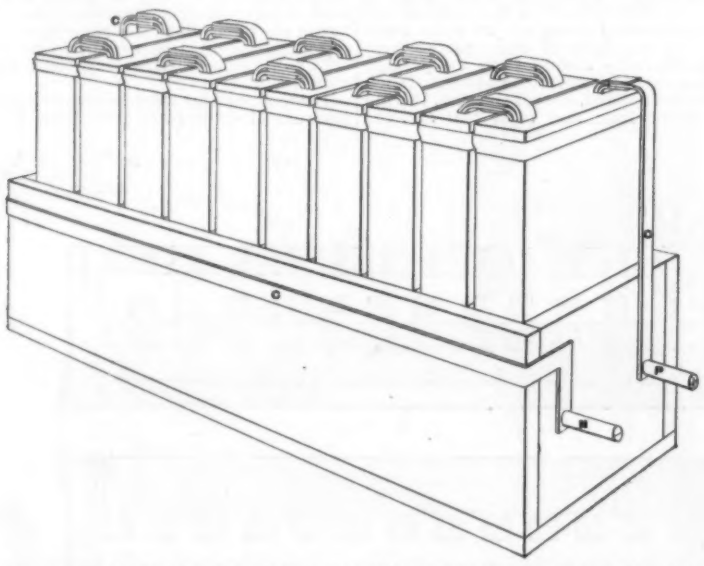


FIG. 23.—TEN CELLS IN BOX, SHOWING TERMINAL CONNECTIONS.

steam packing. The rubber lining is made up on a wooden former, which must be dusted with powdered soapstone to keep the rubber from sticking to it. Bicycle tire cement, such as is used for mending punctures, is applied liberally to the joints and to the outside of the rubber as it stands on the former, and it is then thrust into the tin vessel, which should have a very slight taper to facilitate operations. Of course if there is any leak about a cell of this sort, the acid solution formed by the action of the battery will destroy the metal. When the cell is finished it should be filled nearly full of the electrolyte and tested for leaks by a magneto or battery and bell, one pole being immersed in the liquid and the other connected to the tin. It should be noted that a very high voltage magneto driven very fast will probably ring through such an arrangement even though there be no leak, on account of the large electrostatic capacity of the cell with the fluid in it.

Wooden cells may be used. They should be made of dry white pine about ¼ inch stock, and put together with dowels and pegs, not nails or screws. They may be bound with wire on the outside to strengthen them. After completion they should be immersed for a few minutes in boiling beeswax and rosin, one part of rosin to two of wax, and thus made tight.

The wooden tops of the cells are made of some hard, close-grained stock and thoroughly boiled in the mixture just described. They should be allowed to cool with the mixture adhering to them and then scraped off lightly. The joint between the wooden lid and the outside of the tin can is closed by the rubber band, *R*, Figs. 20 and 21, and the outside of the can should be painted with some good acid-proof paint such as thick black asphalt varnish. A ⅛ inch hole, fitted with an inch or so of glass tube, should be made in each of the wooden cell covers to permit the escape of gases. Fig. 23 shows ten of these cells mounted in a wooden box, the sides and bottom of which are ⅛ inch thick. The ends are ¾ inch thick and the partitions separating the cells ¼ inch thick. The box is 5 inches wide, 5 inches deep, and 19 inches long. At one end is a handle for withdrawing it from the frame, *A* (Fig. 1), and at the other are the two terminals shown at *P* and *N* in Fig 23, which fit into the binding-post, *X*, Fig. 1. Copper strips, *C C*, connect these terminals, which are of brass, ¼ inch diameter and project 1¾ inches to the end terminals of the ten cells. Connection between the cells is made as shown in Fig. 21, the strips being bent over and interlaced, then wrapped with a few turns of small wire, and thoroughly soldered. The surfaces of all the strips should be dusted with powdered rosin before they are interlaced to facilitate the soldering. If the iron is too hot, the lead terminals will be melted, and great care is needed to make a good job.

The electrolyte is a solution of the sulphates of zinc, cadmium, and magnesium. To 1 gallon of water add 2 pounds zinc sulphate, 2 pounds cadmium sulphate, and 4 ounces magnesium sulphate. This fluid is poured into the cells until it stands just above the upper surface of the plates as shown in Fig. 20. The lead plates are the positives, and have to be formed by successive charging and discharging. About twenty charges will be necessary to bring them up to their best working condition. In charging, a current of about 5 amperes should be used and charge kept up until the terminal pressure (all the twenty cells being in series) amounts to 46 volts. It should not be attempted to force it above this figure. Full charge is also indicated by a vigorous "boiling" in the cells. The current should never be kept on after the cells begin to "boil."

The capacity of the batteries will be considerably increased if the lead plates described above are replaced with made-up positive grids, such as are used with commercial storage batteries. These positive plates can be bought of the proper size from most makers of accumulators.

The best battery is, of course, one made by expert workmen in a properly equipped factory. Such cells may be bought from any accumulator manufacturer, and will give better service than those described above, but their cost will be considerable. Should the outfit of accumulators be bought, it should fulfill these specifications:

Amperes at 5 hour discharge, 7; number of cells, 20; ampere hour capacity, 35; weight (total) not to exceed 100 pounds.

For charging with a constant voltage supply at 110 volts, make a resistance of iron wire, about No. 16, B. W. G., of which about 780 feet will be necessary. This should have a resistance (hot) of 13 6 ohms, and will then pass, when connected with the battery in series, a current of 5 amperes at the beginning of the charge. When this current falls to 4·4 amperes, the charge is finished. At first, that is when the battery is new and the plates are not fully formed, the capacity will be very small, the first charge probably not sufficing to drive the vehicle 100 yards. With each successive charge and discharge, however, the capacity of the cells will increase until they will have, when fully formed, capacity for a run of about 20 miles on level ground at low speeds. Hill climbing or spurts of speed use up the power of the battery very rapidly. The highest speed should not be attempted except at rare intervals, the fourth position of the controller, corresponding to *D*, Fig. 16, being the regular running point. This will give a speed of about seven to eight miles per hour on good level roads.

Nothing has been said so far about brakes, it being thought best to leave these to the ingenuity of the builder. They are absolutely necessary, however, and should act upon the rear tires.

If additional points be added to the controller so that the first position back of the open circuit stop position described above connects the motors in parallel with a resistance of about 6 or 8 ohms, made of about No. 18 gage iron wire, the motors running as dynamos will meet with an increasing load as the vehicle speeds, and this arrangement will act as an admirable coasting brake. Another point on the controller short-circuiting the motors will serve as a sudden stop position, but it is not entirely advisable to use this sort of braking for ordinary running, on account of the strain thrown upon motors and gearing, which results eventually in noisy and unsatisfactory operation.

The reverse position of the controller should only be used for stopping in desperate emergencies, as it throws too great a strain upon the spokes of the bicycle wheels.

The total weight of this machine will be about 280 pounds, or 140 pounds on each of the bicycle frames. The total weight with a 160 pound rider will be about 440 pounds, or 220 pounds on each bicycle frame, a weight they should easily withstand even at fair speeds on rough roads.

The design above, while very crude, is yet easily within the power of a person of ordinary mechanical ability to construct. The entire cost of the machine described will only be a small fraction of that of the least expensive motor vehicle on the market.

Charcoal is so porous that it absorbs and condenses gases rapidly. A teaspoonful added to half a glass of water is a remedy for acidity of the stomach, and often relieves sick headache.

IMPROVED TURRET LATHE.

THERE is probably no branch of mechanical engineering, says The London Engineer, to which we are indebted for the accompanying engravings and description, in which foreign competition has been more severely felt than that of machine tool manufacture. That the rivalry has been productive of good cannot be gainsaid, for the toolmakers in this country have somewhat tardily learned a lesson from the way in which the automatic labor saving appliances sent over here from the United States have been taken up by engineers. Messrs. Alfred Herbert, Limited, of Coventry, have laid themselves out extensively for the production of this class of machinery, and the illustrations given herewith will suffice to give a good idea of the success which has attended their efforts. The tool shown is a lathe with a hexagonal turret, and is intended to turn out work up to 2 inches in diameter by 18 inches long, of varied character and in small numbers. Such work has generally had to be done on the ordinary lathe at considerable expense.

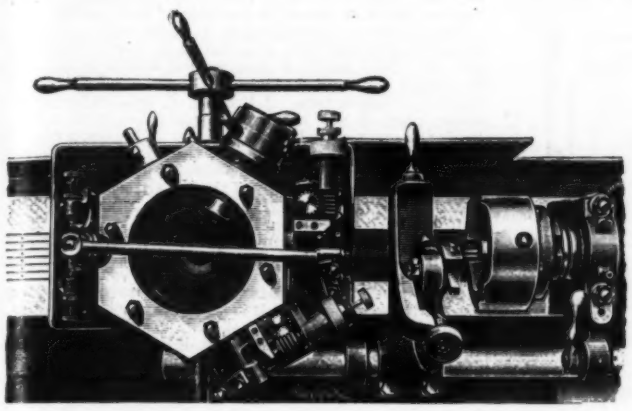


FIG. 1.—VIEW OF TURRET AND TOOLS SEEN FROM ABOVE.

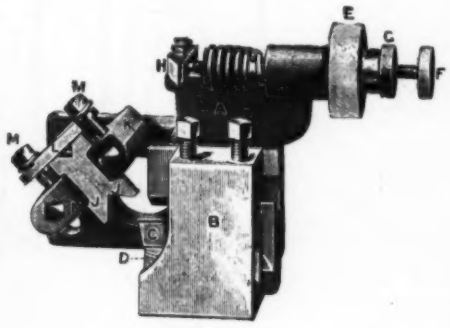


FIG. 2.—TURNING TOOL HOLDER.

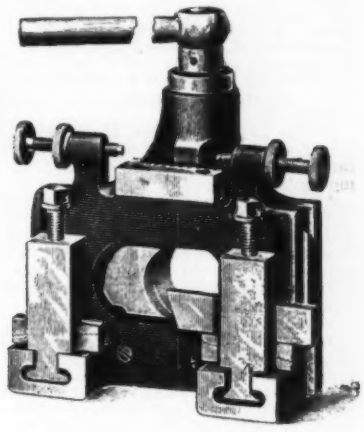
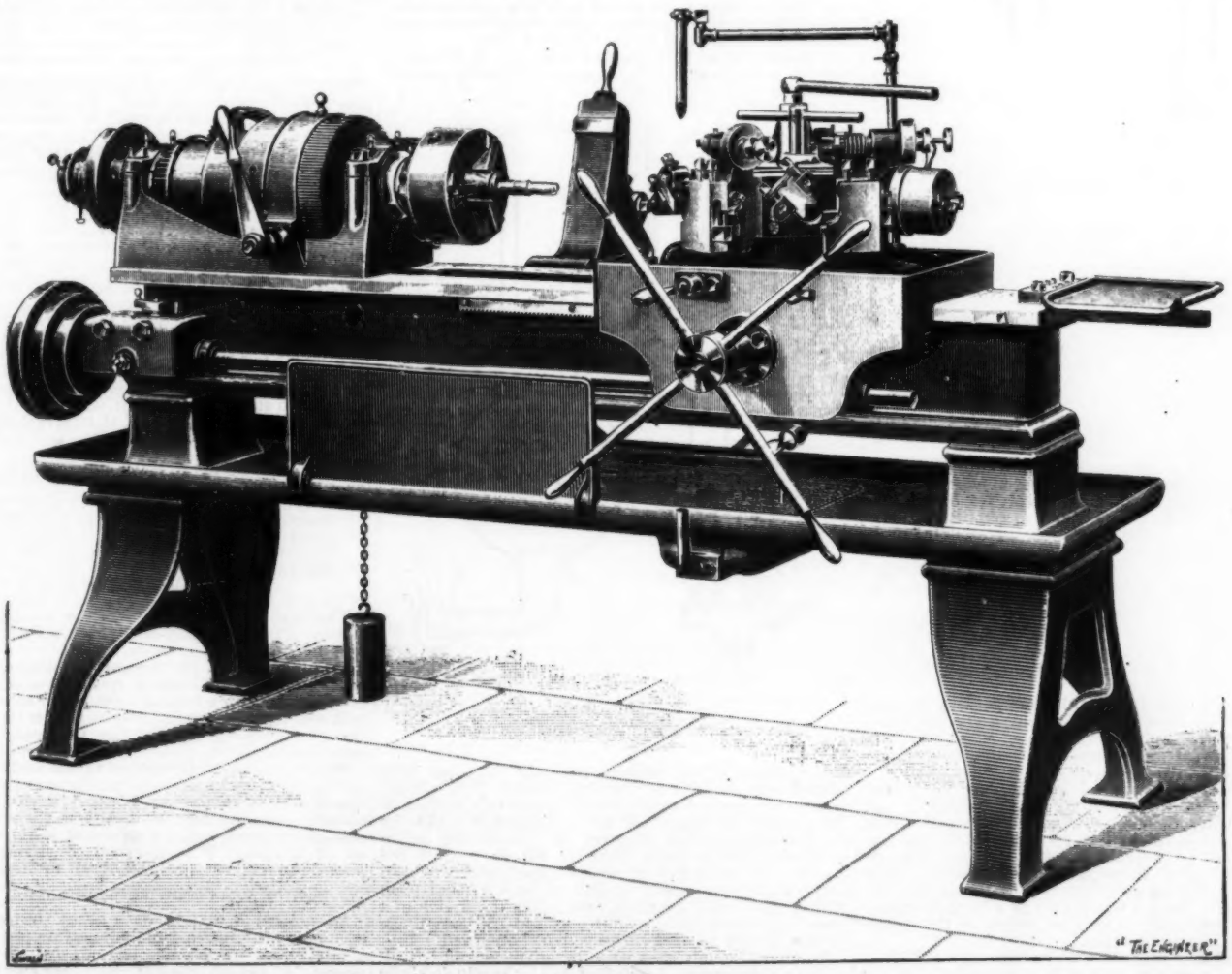


FIG. 3.—CUT-OFF REST.

The general design of the machine is shown by the engravings. The headstock has a three-speed cone pulley taking a 3 inch belt, and is provided with friction back gearing. The bed is of deep and wide section, and is mounted in a large oil tray, which completely surrounds it, catching all the oil and chips. The saddle, of unusual length, slides directly on the bed, the projecting end passing under the chuck enabling the faces of the turret to be brought close up to the chuck jaws; also serves to catch the chips from the cutting tools. The turret, which is the leading feature of the tool, consists of a hexagonal casting fitted to the center of the saddle, the bearing on which it rotates being formed by a large boss cast solid with the turret on its under side and fitting into the saddle. This construction keeps the bearing right below the turret, and permits the bars or finished work of considerable length to pass clear through it from side to side. The engraving (Fig. 1) shows the turret and saddle as seen from above with the standard tools fitted in position. It will be seen that the turret never overhangs the saddle, but is always in the center of it, and moreover that there is only one joint between the turret slide and the bed instead of two, as is the case in ordinary capstan lathes. The locking pin is a hardened steel conical plunger fitting into hardened steel bushes on the under side of the turret. A clamping handle is provided, by which the turret can be clamped absolutely solid with the saddle; but the locking mechanism above described is so firm and rigid that it is not found necessary to use the locking handle except for work of an altogether unusual character. The usual tool holes are bored in the faces of the turret block, central with the lathe spindle, and binding pads are provided so that shank tools such as drills, reamers, etc., can be held in the ordinary way. The automatic feed to the saddle has three changes, and is instantly engaged or disengaged. Six automatic stops are fitted flush with the upper surface of the bed, as clearly shown in Fig. 1. Each of these stops corresponds with one of the turret tools, and only that particular stop relating to the tool actually at work is in engagement. These stops automatically trip the feed at any point, and are thus specially valuable for repetition work. In addition to their function in tripping the feed motion, they also act as dead stops in cases where the turret is being operated by hand.

The tool holders are one of the most important features of the machine. A detailed view of one for turning seen from the front is shown by Fig. 2. It consists of a body casting, *A*, which is bolted to the flat face of the hexagon turret—a projecting boss on the back of the holder fitting into a corresponding recess in the turret face, and insuring the correct position of the former. Cast solid with the body, *A*, is a planed slide, on which fits the cutter holder, *B*, carrying the cutter, *C*, which is held firmly in position by two set-screws, and is regulated for height by serrated packing wedges, *D*. The cutter holder, *B*, is moved along its slide by means of the knurled knob, *E*, and is adjusted with the same facility as a slide rest, to turn any diameter within its capacity. The movement of the cutter is controlled by an adjustable stop screw, *F*, provided with a locking collar, *G*, and abutting against a stop piece, *H*. This stop permits the cutter to be withdrawn after finishing a piece of work, so as not to mark or injure it while running the turret back, with the certainty of returning the cutter exactly to place so as to reproduce the same size on the next piece.

The work is supported while being turned by a pair of steadies, *J J*, sliding in suitable ways planed in a projection, *K*, cast solid with the body, *A*, of the tool holder. These steadies are prevented from falling by a friction piece, which at the same time permits their instant adjustment, and are reversible, one being suitable for small and the other for larger sized work. They are adjusted by the two screws, *M M*, and the swing plate, *L*; the adjusting screws have binding pads and thumb screws for clamping them and preventing them from working loose. The plate, *L*, can be swung round, permitting the steadies to be instantly withdrawn and returned to their exact position. A central hole through the body of the tool holder corresponding with the hole in the face of the turret to which it is attached permits the finished article to pass clear through the tool holder and turret, so that work of considerable length can be turned. Thus the overhang of the tool beyond the turret face is reduced to a minimum. The cutter itself is of a familiar form. Fig. 3 shows the cut-off rest, which is attached to one of the faces of the turret in the same way as the turning tool. Its design is such that the bar need never project unduly from the chuck—a defect which produces faulty work, owing to the spring of the bar. The rest is operated by a lever and steel rack and



HEXAGONAL TURRET LATHE.

pinion, with adjustable stops for each tool. One of the great advantages claimed for this form of cut-off rest is that, being fixed to the turret instead of the bed, it is never in the way except when actually being used; consequently, the other tools can be brought up close to the chuck.

In Fig. 1 the chasing bar for cutting threads of larger diameter than those for which dies are provided is shown in position. It will be observed that this bar takes its bearing directly on the surface of the bed, and is therefore more rigid than usual. There are other minor novel features which the space at our disposal precludes us from alluding to.

THE SELF-MIXING GAS BURNER.

INCANDESCENT lighting with gas by means of the Auer mantle has been improved by M. L. Denayrouze, who has succeeded in obtaining a light of great brilliancy with a small consumption of gas. In order to obtain such a result, he causes a mixture of air and gas, prepared in a special manner, to flow beneath the refractory mantle.

In his first apparatus, M. Denayrouze used an internal force, such as electricity, for actuating an agitator designed to mix the gas and air, molecule with molecule, so to speak.

After continuous experiment, he found that a mechanical device is not indispensable for producing this intimate mixture, nor for realizing the four conditions that the mixture should satisfy. These conditions, which are intimate mixture and proper composition, pressure, and speed, are all united in M. Denayrouze's new apparatus. Before describing the latter, it is well to enter into a few considerations. If we examine the flame coming from the tube, *T*, of a Bunsen burner (Fig. 1), we shall find that it expands in the center and terminates in a point at its apex. In the center there is a blue cone, *a b c*, relatively dark, having as a base a section sensibly equal to that of the diameter of the tube, *T*, and a height that varies with the length of the latter and nearly equal to three times the square root of such length.

All around the dark cone, *a b c*, there is a zone of much lighter flame, *d d*, limited by a nearly translucent surface of revolution, of ovoid form and so much the longer in proportion as the blue cone itself is longer.

The aspect of this flame clearly indicates that in the

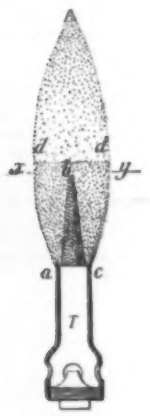


FIG. 1.

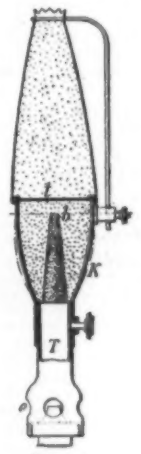


FIG. 2.

FIG. 1.—Flame of a Bunsen Burner.
FIG. 2.—Denayrouze Burner.

whole portion of the flame situated beneath the horizontal plane, *x y*, which passes through the apex of the blue cone the mixture is incomplete, the center having too much gas, and the molecules of air carried along being capable of completely and intimately penetrating the molecules of gas and the upper planes only in starting from this very plane, *x y*.

Moreover, if, in starting from this plane, the jets have the proper quantity of gas, and the best speed, it is clear that, in measure as they ascend, the vicinity of the surrounding cold air will progressively alter, from the periphery to the axis, the composition of the mixture and diminish its ascensional force, as shown by the force of the flame in Fig. 1.

This is why Mr. Denayrouze has surrounded the external surface of the zone, *a c x y* (Fig. 2), with an envelope or chamber, *K*, sensibly embracing the form of the flame, and having its upper edge by preference a little above the apex, *b*, of the dark cone. This chamber is capped with an Auer mantle. In this way, the latter receives only intimately mixed gas and air. The mantle is held as usual by a support, and this is fixed to the side of the additional chamber, *K*.

While the chamber, *K*, has nearly the external form of the ovoid beneath the plane, *x y*, it must be slightly contracted at the base, and then widen gradually and become cylindrical toward its upper edge, starting from *x y*.

Upon making its exit from this chamber, the mixture derived from the elastic gases, taking a vertical direction, assumes the well-known form of the commercial mantle. A disk of wire gauze, *t*, prevents the fire from communicating with the interior.

The tube, *T*, and the chamber, *K*, may be united with solder, or may be made in a single piece; but, when the burner is to be used upon a conduit in which the pressure is variable, it is so constructed that the chamber shall be movable, that is to say, may be displaced by sliding through a socket, upon the tube, *T*. A simple binding screw permits of fixing it at the height desired. As the whole acts as a draught chamber, the admission of air may be varied by the simple displacement of the chamber.

The burner may operate with or without a chimney.

In the first case, the system is so arranged that the action of suction produced by the draught shall be exerted principally upon the air that is obliged to pass into the mantle, *M*, so that the mixture shall be improved and the speed with which it arrives beneath the mantle shall be increased.

To this effect, the chimney, *C*, the lower part of which is transparent, is held by a socket, *B*, which forms part of the burner itself.

The draught of the chimney, *C*, is capable of introducing air at no point of its lower part. Its entire effect makes itself felt at the apertures, *O*, of the base of the tube, *T*. Since these apertures are relatively small, the air is sucked in with force, the mixture is formed better in the chamber, *K*, and the gases make their exit with a speed that may be rendered very great under the mantle, *M*.

The application of a suction of air at the base of the tube, through a chimney closed at its base by a socket (as shown in Fig. 3), causes a heating of the latter

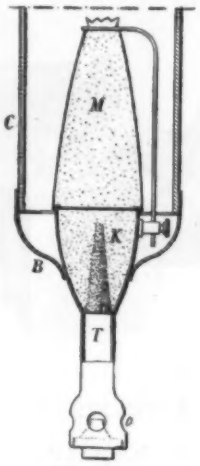


FIG. 3.

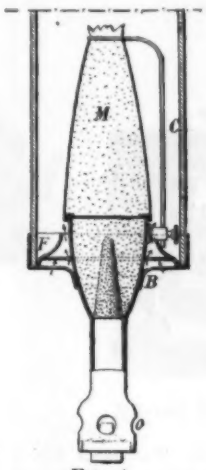


FIG. 4.

FIG. 3.—Burner with a Chimney.
FIG. 4.—Recuperating Burner.

through conductivity, so that it may be advantageously used as a recuperator (Fig. 4). The socket, *B*, carries a sort of recuperating chamber, *F*, provided with a partition. Its bottom contains three oblique apertures which direct around the chamber, *K*, the air that makes its exit hot therefrom throughout the circumference of the mantle, *M*. This hot air finishes the combustion of the particles of gas that traverse the meshes of the mantle without being completely burned. In this way, a dazzling light is produced.

In case the pressure of the gas is very feeble, neither the intimate mixture nor the speed of the gas and air upon their arrival at the mantle is sufficient to produce the illuminating powder desirable. In this case there may be advantageously employed the burner represented in Fig. 5. This is formed, not of a single suction tube, but of several tubes (three in the figure), the upper extremities of which debouch in a single chamber, *G*, of annular form and of a height greater than that of the internal blue flame that would be given by a Bunsen tube formed by each suction tube.

In the center of this annular chamber, *E*, there debouches a simple tube, *T*, through which freely enters,

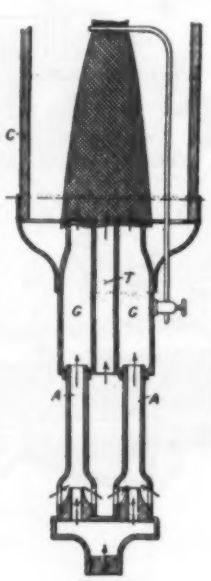


FIG. 5.

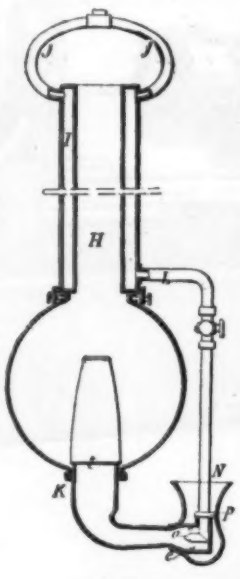


FIG. 6.

FIG. 5.—Multiple Burner.
FIG. 6.—Burner Provided with a Globe.

in the center of the mantle, pure air that has been sucked in in the form of a central column. This column of pure air gently forces toward the external surface of the mantle the mixture of air and gas that makes its exit from the annular chamber, *G*. Under this action of forcing the mixture from the center toward the mantle, the molecules of air and gas penetrate still better and for a greater length of time, so that even with a very feeble pressure, and under the action of a glass that concentrates the draught at the base of the burner, a very great lighting power is obtained.

Another element that may be advantageously utilized in this system for automatically producing the mixture of gas and air is the lost heat of the combustion of the mixture burned under the mantle. This heat is utilized for raising the temperature of the gas and air before they reach the mantle, and for thus increasing the brilliancy, and that, too, without additional expense.

Under the action of these various causes, the mixture rendered perfect, the speed rendered maximum, the preservation of quite a high temperature in the atmosphere surrounding the mantle, and the previous storing up of heat in the elements of the mixture through recuperation, the luminous effect becomes dazzling and the output descends to a few cubic feet of gas only per carcel.

In the arrangement represented in Fig. 6 the mixture of gas and air coming from the Bunsen tube enters a horizontal chamber with a progressively increasing section in which the two fluids make their way in mixing. The mixture is absolutely intimate when it reaches the wire gauze at the base of the mantle.

The mantle is contained in a globe with upturned edges, suspended from a collar that carries the chimney, *H*. The latter is surrounded with a jacket, *I*, at the upper part of which end the tubes, *J J*, through which the gas enters. A branch, *L*, established at the lower part of the crown, and provided with a cock, leads the gas to the Bunsen tube, *o*. Besides, a funnel, *N*, permits of the reheating of the air at the orifice of the Bunsen tube. The mixture of the gas entering through the ajutage and of the air entering through e flows to the chamber, *K*, and thence under the wire gauze, *t*, which precedes the mantle.

The products of combustion, upon rising in the chimney, *H*, heat the gas which passes between the latter and the jacket.

Upon the whole, whatever be the pressure of the gas in the service pipe, it is possible, by means of the arrangements that have just been described, either to create an artificial draught through the escape of the gases of combination, or to utilize the heat disengaged by the burner for raising the temperature of the air that flows around the mantle, or the gas and air that flow under the latter, and thus to obtain the most favorable conditions for getting the greatest amount of light with the least output of gas.

For the above particulars and for the engravings we are indebted to the Revue Industrielle.

SHAVING SOAPS.

THE properties most essential to a good shaving soap are softness, mildness to the skin, economy in use, and the power of retaining a lather for the longest possible time. We may distinguish between shaving soaps properly so called, shaving pastes, and shaving solutions, and proceed to give recipes for each:

SHAVING SOAP.

Purified tallow	90	pounds.
Cocoanut oil (first quality)	10	"
Soda lye	80	"
Potash lye	20	"
Color and scent to taste.		

Most shaving soaps contain cocoanut oil, as this fat is particularly efficacious in making them lather well.

SHAVING PASTE.

Soap	10	pounds.
Alcohol	1	ounce.
Oil of bitter almonds	1¼	"
" bergamot	¾	"
" mace	½	"
" cloves	½	"

Melt the soap with just enough water to convert it into a soft paste when cold. The paste is then well rubbed up in a marble mortar, or passed several times through a kneading machine. This treatment is necessary in order to impart to the soap that fine pearly appearance so much esteemed by consumers of this class of article.

SHAVING LIQUID.

White soap	10	pounds.
Alcohol	20	"
Orange flower water	30	"

Melt up the soap with some of the orange flower water at as low a temperature as possible, and when complete solution has taken place add the rest of the orange flower water and the alcohol. After the finished product has stood for a few hours in a closed vessel it is bottled. Some makers filter the solution, but if very pure materials are taken, and if the solution is allowed to stand and deposit any insoluble matter as we have just recommended, the filtration, which is a long and tedious process, will become quite unnecessary.

Another recipe for shaving liquid is as follows:

White soap	12	pounds.
Essence of fat almonds	1¼	"
Alcohol	6	"
Rose water	6	"
Tincture of amber	2	ounces.
" benzoin	2	"

The manipulation is the same as that described above. The soap may be dyed pink with alkanet or cochineal tincture.

To combine all the properties enumerated above many makers who make a specialty of shaving soaps prepare them at a boiling heat. The following recipe will, however, give good results at low temperature, if the proportions given and the processes described are closely adhered to.

Melt together 200 pounds of tallow and 50 pounds of cocoanut oil, and as soon as the mass is sufficiently liquid add 40 pounds of potash lye (30° Be.) and 100 pounds soda lye (30° Be.) When the soap is thick enough to pour scent with oil of kummel, 1 pound; oil of lavender, 1 pound; oil of thyme (white), ½ pound; fennel oil, ¼ pound.

SHAVING WINDSOR SOAP.

Melt together 400 pounds of tallow and 200 pounds of cocoanut oil. When the temperature is 110° F. stir in a mixture of 340 pounds of soda lye (34° Be.) and 60 pounds of potash lye (30° Be.) When the soap will scum in spite of stirring it is ready for pouring, and this is generally the case in about twenty minutes.

Scent with oil of kummel, 2 pounds; lavender oil, 2½ pounds; and oil of thyme (white), 2 pounds.

YELLOW WINDSOR SOAP.

Treat as above, and at the same temperature, 250 pounds of tallow, 150 pounds of cocoanut oil, 100 pounds of palm oil, and 250 pounds of lye at 37° Be. Scent with oil of lavender, 5 pounds; oil of kummel, 2½ pounds; oil of thyme, 1 pound; and oil of peppermint, 1 pound. If the soap is wanted darker, color with Uranian orange.

Another recipe for shaving Windsor soap, only differing in the scenting, is as follows:

Very pure white tallow	33	pound.
Cocoanut oil (first quality)	16	"
Soda lye (30° Be.)	28	"
Potash lye (30° Be.)	5	"

Scent a few minutes after pouring with essence of carraways, 2½ ounces; essence of bergamot, 3¾ ounces; essence of Portugal, ½ ounce; essence of cloves, ½ ounce; essence of lavender, 1¼ ounces; and essence of thyme, 1¼ ounces. After the soap is set, cut it up, dry the pieces, and rub with a very dry cloth to remove any adherent dust.

THE MILITARY SHAVING SOAP.

Under this name a molten palm soap of very agreeable smell is sold. Five hundred pounds of palm oil soap are melted as above, colored with coloring, and scented with:

Oil of cinnamon	1	pound.
" kummel	1½	"
" lavender	1½	"
" thyme	1	"
" peppermint	½	"
" bergamot	2	"

The soap smells especially good when dry.—Soap-maker and Perfumer.

DIAMONDS IN METEORITES.*

THE attitude of science toward the diamond is most peculiar, the gem presents a subject of deep interest, and upon the problem of its origin and life history all branches of research are engaged.

Tradition has surrounded it with reverence, and named it "the unsubduable;" an exalted estimate of its value is the inheritance of the ages; chemistry, the first of the sciences to throw true light upon it, developed the curious fact that it was composed of but one element, and geology yet utterly refuses to refer it to any of her many eras.

To quote a high authority, "The origin and true geological position of the diamond are unknown. It is always found embedded in gravel and transported materials whose history cannot be traced. It is one of the most remarkable substances known; has been long prized on account of its brilliancy as an ornamental gem; and the discovery of its curious chemical nature confers upon it a high degree of scientific interest."

For the sake of the argument to follow, passing reference to some of its well-known properties is necessary, as, for instance, its superior hardness, its brilliancy, its great specific gravity, its wonderful refractive and optical powers, its unassailableness by any known acid, its transparency and translucency, its infusibility, and, at the same time, in view of all these remarkable properties combined in one substance, the strange facts that in the presence of oxygen it burns as easily as a piece of coal and produces carbonic acid gas, that it is almost identical in composition with charcoal and lampblack, and that Sir George Mackenzie proved that iron and diamond exposed together in a furnace are converted into steel.

Though infusible, yet when protected from oxygen and placed between the poles of a powerful galvanic battery, it is transformed into coke or graphite.

These experiments conclusively prove that diamond is composed of pure carbon—a substance which is very abundant in nature, and which constitutes a large proportion of all organic structures, both animal and vegetable, although it is found pure in but two very dissimilar crystallized forms, diamond and graphite or plumbago.

The latter is a somewhat rare mineral, and in its still more rare crystals has the figure of a short, six-sided prism, bearing no geometrical relation to the cube or octahedron of the diamond.

Crystals of graphite are found associated with other forms of carbon, but the diamond never. It dwells alone in its glory and forms no connections with its carbon relatives which are not of unmixed composition.

All other precious gems are transparent crystals of materials similar to the masses in which they are found. The ruby, sapphire and topaz are composed of alumina, iron, and lime. The emerald and beryl, of silica, alumina, glucina, iron, lime, chrome, magnesia, and soda. It will be observed that the diamond, however, is unique in being the pure form of only one element, while all other gems are composite.

Geographically considered, the diamond is most interesting, and a very curious series of facts present themselves.

It is found in the three great peninsulas which project into the southern watery half of the globe—India, Africa, and Brazil; and in all the islands of those seas, quite recently and notably in Borneo.

At once the strange fact appears that the diamond is found only upon one side of the earth. A few isolated exceptions, to be hereinafter noted, do not affect this remarkable circumstance, which any theory of the origin of the diamond must perforce explain.

In these countries it is found only in river beds and valleys, among debris and drift with which it has no chemical or geological affinity, and on the mountain tops from whence the rivers arise.

Science declares that the diamond has never been found in its matrix, and no theory of its origin has ever been advanced. What do these words mean, or rather, what do they not mean? They mean that upon the earth the diamond is not in its native home.

Are there any assured facts to guide to a solution of this problem and to trace its origin to other worlds than ours?

Ever since it was known that the gem is pure carbon in a crystallized form, the idea of producing it artificially has charmed the intellects of scientists. Moissan, in 1892, first succeeded in manufacturing them by a complicated process, which it would require much time to describe in detail. Suffice is to say that with iron, sugar-charcoal, 5400° of heat, powerful electricity, enormous pressure and sudden cooling, he conducted a wonderful experiment and produced minute crystals of diamond. About the same time, Kroutchoff in Russia obtained the same result with silver instead of iron, showing conclusively that neither the iron nor silver had anything to do with the formation of the carbon crystals, which were manufactured directly from the sugar-charcoal.

These experiments have demonstrated that sudden cooling under enormous pressure is necessary to the process of diamond making, and these conditions in a molten liquid or gaseous earth, or in any more recent eras, are impossible; as the globe is never subject to sudden changes of temperature, while its methods of rock building and chemical operations are slow in action and its cooling has been very gradual.

Most of the world's great storehouses of carbon in the form of coal and graphite are on the opposite side of the earth from where the diamond is found, and in these huge deposits no carbon crystals appear, neither were such crystals ever formed in the presence of oxygen.

This fact, with the before-mentioned sudden cooling necessary to the process of diamond building, points to an extra-terrestrial origin for the beautiful gem.

These things alone would not warrant the search into infinite space for the birthplace of any supposed terrestrial substance were it not for the fact that diamonds have actually fallen from the skies upon the earth, and more than once.

Since, then, there is the positive knowledge that they are manufactured in space, the natural inquiry follows, Whence came they to earth, and when?

A meteorite fell in Careote, Chile, which contained carbon in organic substances soluble in ether, and also an elementary crystalline form of carbon, dull black and very hard, which was in reality a variety of black diamond.

A recent attempt to polish fragments of the great meteorite of Cañon Diabolo, Arizona, resulted in the destruction of the emery wheel, and the discovery of minute black particles throughout its substance, which proved to be genuine diamonds.

Two perfect little octahedrons exploded on exposure to the air of a warm room. The little gems had evidently been formed subject to great pressure, at a much reduced temperature, as before explained, and their cohesion was not sufficient to resist the changed conditions, thus conclusively proving Moissan's experiment, and also exhibiting in an exaggerated degree the conditions of an increased tension within, which Sir David Brewster long ago observed to exist in all diamonds.

Here, in this mass of iron, was Moissan's experiment certainly performed in some starry or cometary laboratory.

Another meteorite in Siberia also contained diamond crystals; so there are already three to witness to the wonderful truth.

Since diamonds are thus traced to meteorites, it becomes necessary to understand these interplanetary bodies in order to open another chapter in the life history of the gems. While their presence in such strange company would be as much or more of a mystery than their position on the earth, yet it is certainly a great step in advance to have recognized them as terrestrial visitants and not natives.

That they are chemically entirely foreign to the meteoric iron is also quite evident; neither is iron in any manner necessary to their formation, since Kroutchoff used silver in his successful experiment already mentioned. Yet even all these things, however important, if alone, could tell us nothing of the place of their nativity.

Prof. Henry Carvill Lewis, whom it will be necessary to quote several times, says in "The Diamond," 1897: "The diamond must have had its carbon from the atmosphere as original source, reasoning from the material in which the diamond-bearing pipes of Kimberly, South Africa, occur."

Meteorites fall upon all parts of the earth, and from any direction in the heavens; and the air, whenever or wherever it is analyzed, gives up a portion of meteoric iron; for many of these flying visitants are totally consumed in the earth's gaseous envelope and reduced to impalpable powder which the air sustains in its embrace and carries upon its currents.

While these things are true of meteors in general and are in accord with all other facts, yet it is known that they follow certain laws and observe known periods. In 1867, Schiaparelli discovered that meteor showers resembled and followed the orbits of comets, and soon demonstrated the fact to astronomers, even identifying the comets in whose trains the August and November meteors travel.

By finding diamond crystals in meteorites, they are thus traced directly to comets, for no astronomical conclusion is better established than that meteors are the fragments or followers of comets, and do not leave their orbits any more than a planet will break the bonds which chain it to the sun and fly in a tangent from its appointed path among his system of worlds.

Iron that falls from the heavens in meteorites is always of a crystalline structure totally different from any of the forms it assumes on the earth, and so also with certain easily recognized meteoric metallic salts and resins utterly unknown here.

Since, then, such a well-known element as iron displays peculiar forms under the influences extant in interplanetary space, where almost immeasurable speed, such as comets attain on nearing the sun, in one instance equaling 400 miles a second, develops a degree of heat and electricity which cannot be computed, while, at the same time, the flying mass is swept by a blast of cold ether, variously reckoned as from 200° to 1,000° degrees below zero, it would be strange, indeed, if carbon did not also manifest itself in forms equally as different as the conditions themselves. It will be observed that these conditions are exactly those required by Moissan's experiment, viz., iron, carbon, heat, electricity, and sudden cold.

Sir David Brewster attributed the traces of double refraction which are exhibited by the interior of the diamond, while it only possesses single refractive powers in its exterior layers, to a peculiar tension imparted to the interior of the crystal during its formation. This explanation is still received, as it is the only possible one of the strange difference, while it is also itself explained by the conditions known to exist in meteorites and comets; but no such conditions in a molten earth are even supposable.

While meteorites thus bring to the earth solid samples of the substance of comets, with a marvelous tale of the conditions which their structure unfolds, the spectroscope, that revealer of the mysteries of the earth and the heavens, whose penetrating eye compels light to give up the secrets of its source, with the laws of its motion and rate of vibration, that wonderful instrument, which has created the science of the age, when turned upon a comet confirms the testimony of the fallen meteor.

This intimate connection between comets and meteors is perhaps the most striking and novel discovery of a purely astronomical character made in this century, and is certainly fraught with more meaning to humanity than almost any discovery of any age.

Sir John Herschel regarded comets as masses of vapor or gas, but since his time science has been forced to admit that they may have solid portions, and the spectroscope shows them to vary greatly in composition.

Prof. Huggins has proved by experiments and observation that hydrocarbon forms a large proportion of the heads of some comets, notably of that one celebrated as Encke's, and of two others that he examined.

There thus appears the certainty that meteorites follow so truly in the trains of known comets that their periodicity can be equally calculated, with the further certainty that the substance of comets and the conditions extant in them are exactly the material and conditions necessary to produce the diamonds which meteorites have brought to the earth.

Maupertuis, a French astronomer, writing in 1742 of the possible collision of a comet with the earth, said:

"However dangerous the shock of a comet, the comet itself might nevertheless be so small as to be fatal only to that part of the earth with which it happened to come in contact; so that we might perhaps be compensated for the destruction of some kingdom, by the enjoyment which the rest of the world would derive by the rarities which a body coming from so vast a distance could not fail to bring with it.

"The débris of those masses which we despise might prove, to the surprise of everyone, to be formed of gold and diamonds."

It is remarkable that more than a hundred and fifty years after he wrote those words diamonds actually fell upon the earth as meteoric messengers from the comets of infinite space, while the spectroscope tells of matter and conditions necessary for their manufacture in those wonderful bodies, and has revealed gold in the sun.

Though diamonds are thus traced directly to comets, there remains yet unexplained the strange fact of their superficial position upon one side of the earth only.

The diamonds that meteorites bring are small and black, while the glorious gems of the southern hemisphere are white as the light; there are, however, among them rare red and blue and green crystals, and the still more highly prized black gem, which last at once identifies and connects them with the dusky diamonds of meteorites.

They are principally located in a zone around the earth of about 20° in width and encircling the water half of the planet. The zone extends north of the equator on the Asiatic continent and dips below it on the American side.

In Brazil, Africa, India, and nearly all the islands of the southern oceans, are these crystals found; on the tops of the highest mountains, on bare rocks, and in valleys, amid sand, stones, clay, and débris entirely of recent deposit and evidently not in their matrix.

It is, therefore, in an era later than any geological age must the search be made for another link in the history of the diamond.

The peculiar conglomerate called diabase or gabbro, in which the diamonds of South Africa are embedded, is known to be of recent formation, and that it is not the matrix of the gems is proved by a large proportion of them being broken and isolated fragments.

It has been lately suggested that this is volcanic in origin, but who can admit that volcanic action could produce a crystal of carbon which the presence of oxygen to feed the flames would inevitably have consumed and transformed?

Prof. Carvill Lewis found the diamond-bearing pipes of Kimberly in close proximity to masses of basalt and shale with true eruptive rock, but none of these inclosed diamonds. He also speaks of the remarkable rock in which diamonds are found as their matrix, though few other authorities agree with him upon this point, but he also has said, as before quoted, that their carbon was of atmospheric origin. He also abundantly proves the most remarkable resemblance between the peculiar Kimberly rock and true meteorites in the case of bronzite and a number of other substances, with numerous characteristics which are found in common with this formation and meteorites, and through this, diamond crystals, often fragmentary, are irregularly scattered. Others argue that such a rock is certainly not of volcanic origin.

The unique character of these diamond-bearing pipes with the crystalline and peculiar microscopical form of their component materials, like other known meteoric masses, is a most powerful argument that the whole formation is also itself meteoric.

The author says: "Perhaps the most interesting chemical observation concerning the 'blue ground' (surrounding and uniting these minerals) was that made by Sir H. E. Roscoe. He found that on treating it with hot water, an aromatic hydrocarbon could be extracted. By digesting the 'blue ground' with ether and allowing the solution to evaporate, this hydrocarbon was separated and found to be crystalline, strongly aromatic, volatile, burning with a smoky flame, and melting at 50° Centigrade."

This is a powerful reminder of the hydrocarbons of

* Read before the American Society for the Advancement of Science at Harvard University, August 26, 1898, by Mrs. E. M. Sonvielle, Jacksonville, Fla.

comets, and its peculiar nature seems to have no parallel on the planet.

The author also insists that "the structure is not purely mechanical, as is the case with rocks which have been subject to great pressure."

It is more than probable that, in a volcanic region like South Africa, volcanic action has moved, broken, and otherwise disturbed this mass, which owes nothing else to volcanic agency.

It is emphatically said by Lewis that the Kimberite shares its characteristics with no other terrestrial rock and strongly resembles meteorites of similar construction.

It will be observed that the evidence which Prof. Lewis educes points most positively in one direction only, and that is precisely parallel with the argument of this paper.

THE DECORAH ICE CAVE AND ITS EXPLANATION.

By ALOIS F. KOVARIK, Decorah Institute.

ONE of the greatest natural curiosities in Iowa is the Ice Cave at Decorah—a town situated in a most beautiful valley surrounded on all sides by Nature's picturesque sceneries. Hundreds of people visit the Decorah Ice Cave, year after year, and there are thousands who visited it in the years past. The curious phenomenon draws the attention of the tourists as well as of the scientists hearing of it, and excites the desire to visit the cave.

In the spring and the summer of the year this cave contains quite a large quantity of ice frozen to one of its walls, and as the annum passes through the latter half of autumn and the first part of winter, it is dry, and the temperature considerably above freezing.

The Decorah Ice Cave is located on the south side of a bluff at an elevation of 27 to 36 meters above the river level. The bluff, which is north of the city, runs east and west along the upper Iowa River, and is about 84 meters high above the river level. That part of the bluff wherein the cave is found is a marked fault for about 200 meters, and the Trenton rock reveals its bareness to the observing eye in the valley below. The cave is very near the eastern end of the fault.

One of the paths leading to the Ice Cave is via Ice Cave Bridge, in the northeastern part of the city. Following this path, which leads at quite an elevation along the bluffs, one may get a beautiful view of the valley with its city below. Immediately below the entrance, this path is an uphill path of crumpled rock, at the end of which are two walls of solid rock rising to a height of about 12 meters and running parallel to each other in the direction of northwest for a distance of 10 meters, where the upper parts come together and form the opening into the cave, 1·4 meters high. Naturally this opening was small, but to give easier entrance, it was enlarged to its present size (see the photograph of the entrance. The opening is in the rear and cannot be distinctly seen in the picture).

With a view to gather the facts about the different changes in temperature and phenomenon in the Ice Cave and to ascertain the true cause of this phenomenon, I made regular excursions to the cave once in every two or three weeks, beginning with July, 1897, and continuing till nearly the present time, after having occasionally visited the cave during the years previous.

Having studied the origin, the position, and the different variations in the phenomenon, I formulated a theory which I give below, and which, it seems to me, explains truly the cause of the phenomenon.

It was on July 1, 1897, that I visited the cave for the first time with a view of scientific investigation. The cold breeze coming from the cave was noticed on the path below, 30 or more meters from the entrance, and grew stronger as I approached the entrance, at which a cloud of condensed vapor rushing from the cave met all visitors of that day, and brought a sight of surprise and wonder on the faces of those that noticed the beauty of the view. At the very entrance the breeze was so strong as to make it impossible to light an ordinary match, and, near the floor, would even blow out the flame of a candle. Such a breeze and such a cloud of condensed vapor were not noticed throughout the year. Nay, even December 11, 1897, reverse was the draught, i. e., into the cave, and thus continued till February 26, 1898, while the cloud of condensed vapor was noticed only on very warm days.

Entering the cave, the path has the direction east-west, and slopes its whole length, the descent at the forking of the path, a place 12 meters from the entrance, is 1·5 meters, while the very end of the cave is about 3½ meters below the entrance. The walls of this chamber are of solid rock (except the highest parts of the south wall), and on average 2 meters apart at the base, but meeting at a height of many meters, forming a sharp diedral angle. July 1, 1897, and during the whole summer, these walls were covered with heavy moisture, which was gradually disappearing during the fall, so that, after October 30, I noticed the walls dry, and likewise through most of the winter following.

In February, 1898, moisture, in form of frost, appeared on the walls, the temperature (see table) then being below freezing.

On entering the cave on the 12th of the following month, I was greatly amazed by Nature's grand view offered to be looked upon. The walls throughout the cave were covered with heavy frost of various shapes and sizes, which reflected the light of my candle, producing an excellent effect.

With the approach of spring days, the quantity and the beauty of the frost speedily diminished in this chamber, till only moisture was left behind.

As stated supra, the path forks into two branches. One, the shorter, leads southward into a small chamber, the "Daylight Chamber." In this ramification of the cave, if looking upward, one may see the daylight as reflected by the rocks above. The other branch leads straight westward into the Ice Chamber. Just by the side of a large Trenton rock standing isolated from the wall, the path has a sudden descent of 1·5 meters, where a rock of dangerous appearance overhangs the path quite low, making it necessary to bend to the floor in order to enter the Ice Chamber.

The crevice above the Daylight Chamber is on the margin of the fault, and is 3 meters long, running westward.

In the Ice Chamber the south wall, which is not totally of solid rock, curves over the path, and rests on the solid, nearly vertical, north wall. Here the path is somewhat narrower than heretofore, and the roof of the cave at an average height of only 1·6 meters above the floor.

At 6 meters from the division is the "Locus Glacialis," where, during the spring and fore part of the summer, ice covers the north wall from the very top to the very base and about two meters in width. The thickness of the ice varies with the part of the season; also, with the place on the wall, being greatest at about the

ENTRANCE TO THE DECORAH ICE CAVE.

middle point of the ice surface. The maximum thickness in 1897 was probably July 1, when it was about 25 cm. From then it gradually decreased, so that July 17 it was only 15 cm.; July 24, 10 cm.; and by September 3, all the ice disappeared. After September 3 the temperature in the cave was continually rising till October 16, when it reached its highest point, + 8·3° C., or about the temperature of a cold spring; from thence, a gradual decrease in temperature continued till the time of its lowest point. This was February 26, 1898, when the thermometer showed —6·6° C.

This year the ice at Locus Glacialis first appeared about May 29. Two weeks before that time water was dripping from the crevices between the north and the south walls. Beginning with May 29, the ice rapidly increased in mass, that by June 12, the time of maximum quantity, the ice covered the wall for a width of nearly two meters, having the greatest thickness of 29 cm. (see flash photograph of the Ice Chamber, taken specially for this MS.; the thermometer is about in the middle point of the ice surface). Very rapid decrease was going on last summer: July 16, only a small quantity was found, and this mainly at the foot of the wall, and by August 1 all the ice disappeared.

At 6·6 meters from Locus Glacialis is the place where ice in the spring makes its first appearance in the cave—this year, March 26. In summer, from the hole, a strong current of air into the cave was noticed. To find out how far this opening led, I crawled through the small opening leading northward, but was soon checked by a wall of solid Trenton rock. Here is the end of the cave. The total length of the cave is 31 meters. While ice is found at Locus Glacialis and at one other place, the rest of the walls of the Ice Chamber are heavily covered with a beautifully crystallized, hoary frost, which, with its fancy shapes and various sizes, along with the ice on the wall, glisten in the light of a candle and give a beautiful scene to the Ice Chamber. By placing a candle and viewing the chamber from the rock which overhangs the path, I found I had the best view of the whole chamber, and, when I had the flash photograph taken, I left a candle burning and it shows as a white spot in the picture.

Temperature.—To give some idea about the temperature in the cave at different parts of the year, I give below the results of my last year's observation in degrees Centigrade:

Time.	In the Valley. (Shade.)	Division.	Locus Glacialis.	End.
July 1, 1897	+33·3	+2·2	0·0	0·0
July 27, 1897	+21·1	+5·0	0·0	0·0
August 14, 1897	+32·2	+5·8	+3·1	0·0
September 3, 1897	+32·2	+7·2	+3·1	+8·3
September 18, 1897	+33·9	+8·6	+6·1	+8·3
October 16, 1897	+24·0	+10·0	+8·3	+8·3
October 30, 1897	+10·0	+7·2	+4·7	+5·0
December 11, 1897	—2·2	—2·7	—1·1	—2·2
January 8, 1898	0·0	—2·7	—3·9	0·0
January 22, 1898	—5·0	—6·1	—3·9	—3·9
February 26, 1898	0·0	—6·6	—6·6	—5·0
March 12, 1898	+2·8	—1·6	—2·7	—2·7
March 26, 1898	+8·8	—1·7	—1·6	—1·1
April 16, 1898	+25·6	—1·4	+1·1	—1·1
April 30, 1898	+13·9	+1·1	—1·1	—1·1
May 28, 1898	+17·2	+1·7	—0·3	0·0
June 9, 1898	+25·0	+1·7	—0·3	0·0
June 18, 1898	+28·3	+1·7	—0·2	0·0
July 16, 1898	+35·0	+7·2	0·0	+2·2

Origin.—The origin of the cave is undoubtedly due to the slip of the southern part of the bluff, caused by the undermining of the river. This is shown on the outside; also, in the Ice Chamber of the cave, where the south wall curves over the path and rests on the solid north wall. Besides, the direction of the cave is westward—the direction of the fault. No signs, outside nor inside, are there that would indicate that it was formed by erosion. The Ice Chamber is at a depth of nearly uniform temperature throughout the year, namely, about +9° C.

THEORY.

Theories were advanced to explain the phenomenon of the Ice Cave. For explaining the cause of the formation of ice in the Decorah Ice Cave, and in any ice cave so far reported, some of the proposed theories are absolutely untenable. I shall not touch upon these in this paper, as they have been discussed to some extent in Mr. Batch's "Ice Caves and the Causes of Subterranean Ice."

As in different years there are changes in some things relating to the phenomenon, such as the dates of the first appearance of ice, the maximum quantity, the lowest and highest temperatures, etc., and the changes in temperature in general, we must have a true description of the variations throughout one year at least before we can safely draw conclusions. The facts noticed about the Ice Cave during the past year I briefly stated above, and likewise I give below my conclusions.

The density of air and gravitation cause the currents into and out the cave. If the denser air is within the cave, the natural flow is outward, and inward when reverse are the conditions. The strong breeze outward and the cloud of condensed vapor on a hot day in

DECORAH ICE CAVE—LOCUS GLACIALIS.

June or July is due to the great difference in temperature (outside and inside the cave), sometimes exceeding 34° C. To the difference in temperature is also accounted the moisture on the walls. There being many small ramifications of the cave, besides the main passage, the cold air of the winter penetrates these and actually freezes the walls of the cave to a great depth. The air passing through the cave gradually changes its temperature to the temperature of the surroundings, and then escapes through the opening in the Daylight Chamber and also, though probably less, through the hole, through little crevices, out above the bluff. In this way the walls of the cave come in direct contact with the cold atmosphere of the winter and store

up in themselves a great amount of "cold" for the use in summer, when reverse takes place.

The length of duration of the ice in the cave during the spring and summer depends upon the quantity of "cold" stored up in the walls, and this, again, upon the "coldness" and the length of coldness of the previous winter. If the winter be severe and long, the walls will store up a great supply of "cold" for the gradual dissipation in the spring and summer, and consequently, the phenomenon of the ice in the Ice Chamber will last longer. Last winter, with an exception of the fore part of December, was quite mild. As a result, the ice began to disappear with the latter part of June, and totally disappeared by the end of July. Through information I learned that during the years 1886 and 1887, the Ice Cave contained especially a great amount of ice. This is apparent, as the winters previous were remarkably severe for this locality and a vast amount of snow covered the ground.

The time of the lowest temperature in the cave depends upon how soon the cold spells of the winter begin; for the sooner the walls begin to freeze to a greater depth, the sooner have they stored up the greatest amount of cold, caeteris paribus.

Last winter the cold spells were during December, and the lowest temperature noticed was on February 26, 1898. In the winter of 1896 and 1897 the coldest spells came about the end of January, and the lowest temperature was in April; same (according to W. O. Nordheim, of Decorah) was true in 1895.

February 28, 1898, when the walls contained the greatest amount of "cold," there was no ice in the cave, for the reason that no water made appearance. Could water have appeared, no doubt a great amount of ice would have formed; but, as the conditions are, the water has to come from the ground outside, and this low temperature in the cave in summer to the storage of cold in the walls communicated to them by the cold air of the winter having a place to enter and a place to escape.

I hold it true that it is the cold of the winter that is the cause of the formation of ice in any ice cave, for no ice caves are reported from places where there is no winter, while ice caves are found in France and Switzerland, where winter prevails through part of the year, and, furthermore, that the cold from the outside reaches the interior, either directly through the rock (in which case the cave cannot be at a great depth), or more likely is brought in by the air, not necessarily through the ice cave proper, though possibly, but probably through crevices near the walls of the interior, so as to freeze them and thus affect the temperature inside.

That evaporation and expansion may aid I will not dispute, but I absolutely disbelieve that they are the only causes. In August and September the breeze still penetrates the cave, water is still found in the cave, but no ice forms.

Note.—In the southern part of town is an ice well in which, during summer, ice is found. Explanation similar to the cave I would apply here. I hope this paper will please all who take interest in caves, and ice caves especially.

BIRDS OF PREY IN THE ZOOLOGICAL GARDENS OF COLOGNE.

IN the well-stocked division for birds of prey in the zoological gardens of Cologne many rare species have been recently exhibited, of which the accompanying illustrations represent several of the most interesting.

First, we have the Bengal vulture (Gyps bengalensis Gm.), in size about as large as an average turkey and in color a dark gray. The tail-feathers are black; the strong legs, white; the talons, a light grayish-blue. The slender, downy neck is encircled by a stately, pure white ruff of feathers, which ruff is lengthened somewhat at the nape of the neck.

Among the owls, the South American mask owl is characterized by its queer, squat form and the mask-like, black and white markings of the face. The blue-gray beak is half hidden in a feathery white beard; the bright yellowish-white spot on the throat is sharply outlined on both sides by a dark brown cross-band. The abdomen is colored a monotonous yellowish gray; the rough claws, almost naked, a gray-blue; the iris, a bright nut-brown; and the crown of the head, a jet black. The mask owl attains about two-thirds the size of a horned owl and generally squats in a low posture.

Among the birds of prey seeking their food by day may be mentioned the peculiar and rare Cheela hawk (Spilornis Cheela), indigenous to India and Southern China. This bird surpasses the buzzard in size and is distinguished by its proud carriage. The long feathers over the eyes, when the bird moves, are raised sidewise and upward, causing the face to assume a singular expression, almost like that of a horned owl. The head is colored a dark brown. From the deep black facial disks, the white-gray iris and the white-blue beak stand forth prominently. The breast and abdomen are gray-yellow in color, with irregular short cross-lines and points of a faint blackish color. The back is colored a dark brown; the flag and tail feathers, a jet black, the latter being crossed by a white band and tipped with white; the talons are dark gray.

The Bacha hawk (Spilornis bacha, Gray) resembles the Cheela hawk in size, carriage, and color, but lacks the tuft-like, lateral head-feathers. In moving about the bird raises the elongated feathers of the nape of the neck and of the crown upwardly. The color of this hawk is brown. The abdomen, as well as the coverts of the wings, are spotted white; the iris is dark; and the talons a gray-yellow. The Bacha hawk is indigenous to Java.—Illustrirte Zeitung.

MAMMALS.*

THOUGH mammals are the highest class of vertebrates their organs are not all necessarily more highly developed than in all other vertebrata. Many a mammal's eye is not as well developed as the eagle's, and other organs in certain mammals are far surpassed in members of the lower group; but, taking them altogether, the mammal is the most complicated of the animal kingdom, exhibiting greater specialization. There has never been any common name for "mammals," the term being of comparatively recent origin, derived directly from the Latin "mammalia." The term "quadruped" is one recently applied to this group, but does not exactly cover the ground as mammalia; because such animals as the whale and bat, though mammalians, are not quadrupeds; one swims, the other flies; and they have not, strictly speaking, four feet.

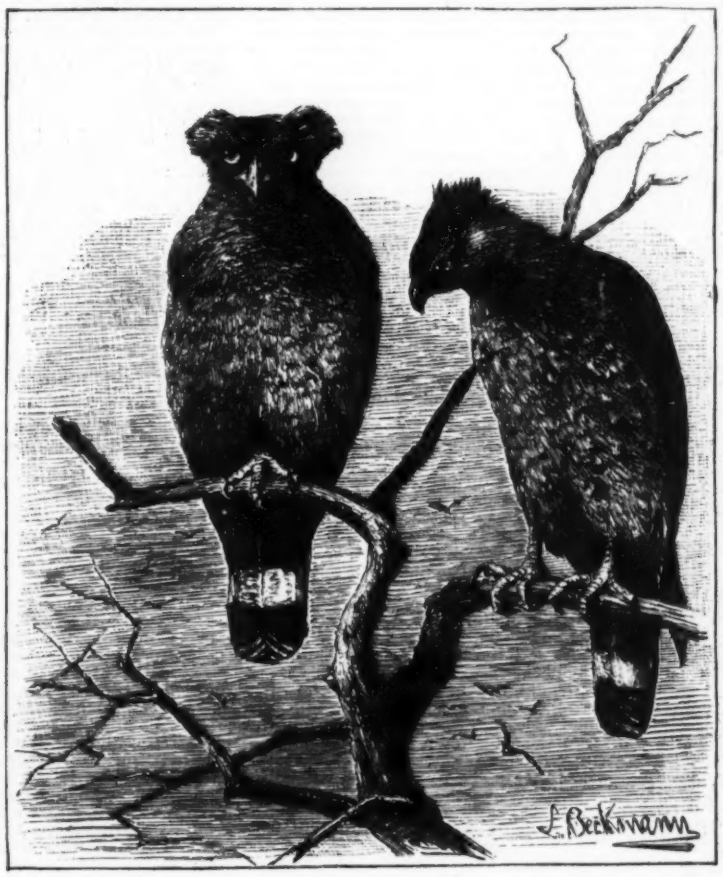
In mammals the young is nourished by milk secured from the body of the mother and their backs wear a hairy covering, as opposed to the feathery covering of birds and the scaly covering of reptiles and fishes. Every mammal is at least partially covered with hair. We find hair in the young whales, while in the adult there is no trace whatever; but in all the other species the hair is present. The feather grows to its full size and then practically dries up and in the course of the year falls off, and is replaced by an entirely new feather at the next annual moult of the bird; but in the case of mammals the hair—while it may be cut, or worn, off—grows continuously out from the base, so long as it remains attached to the body.

In every known mammal (with three exceptions) no matter what the apparent length of the neck, there are only seven vertebræ. The exceptions are: The manatee, which formerly inhabited the waters of Florida, and was somewhat allied to the whales and porpoises, and two species of sloth. The manatee and one of the sloths have only six neck vertebræ; the other sloth has nine. The number of bones in the giraffe's neck and that of the whale is exactly the same, the only difference being the form.

The hair covering of animals is subject to great variation. In the cats a number of the hairs of nose and mouth are stiffened into a sort of bristles having nerves at their base; so that these bristles or hairs are really organs of touch in all the cat kind. Many of the porcupine's hairs are converted into quills, serving as a means of defense. In the rhinoceros the hairs of the nose are matted together and hardened into an immense horn. By making a vertical section through the horn its hairy structure may readily be seen. The hoofs and horns of cows are merely a modification of the hairy covering.

Birds, when perching, grasp the branch entirely by the toes, from which extend the metatarsal bones in the bare part of the first leg seen reaching up. In such animals as walk on the tips of the toes these metatarsal

Bengal Vulture. Mask Owl.



Cheela Hawk. Bacha Hawk.

RARE BIRDS OF PREY IN THE ZOOLOGICAL GARDENS OF COLOGNE.

* Abstract prepared for the SCIENTIFIC AMERICAN SUPPLEMENT from a lecture by Prof. Witmer Stone, at the Academy of Natural Sciences, Philadelphia.

bones are joined together in one bone, in the same manner as birds. The horse and cow walk on the tips of the toes, with the heel highly elevated; and the metatarsal bones are more or less fused together, in one solid bone; while in birds no such union takes place. The mammals are variously termed "plantigrade" (those walking on the whole foot) and "digitigrade" (those walking on the toes).

The duck-bill, of Australia, which has a peculiar duck-bill jaw, burrows in the banks of the rivers in the manner of our musk rat, and has the fore feet distinctly webbed. The tail is very broad and flat, looking like a continuation of the back, and probably assists the animal in swimming. The teeth are entirely wanting in the front part of the jaw; and there are some flat teeth, corresponding to the molars, in the hinder part—being merely flat plates. The mode of reproduction is extremely interesting. In all the other mammals, including the marsupialia and monodelphia, the young are born alive and then nourished by the parent; but, in the duck-bill, eggs are laid in the same fashion as reptiles and birds, and the young are hatched in nests. The young duck-bill is provided with a hard, horny knob on the tip of the bill, exactly as in the case of the ordinary birds, with which it breaks through the egg shell.

The marsupial animals are (with the exception of the opossum) all restricted to Australia, and are ancient, primitive animals. Large numbers of fossils found indicate there were formerly many more than now. They persisted in Australia because, after their introduction into that continent, it was probably separated from Asia in the condition in which we find it at present; and the flesh-eating animals were unable to enter Australia on account of the water barrier which they met; and so these marsupials, which were unable to protect themselves in the other continents against the flesh eaters, continued to exist in Australia after being practically exterminated elsewhere. In Australia to-day there are vast numbers of forms of marsupials—the kangaroo being the most typical. Other forms bear very close external resemblance to the squirrels; one species, found in Catalonia, resembles a small wolf; and in 1896 they discovered a marsupial mole—a very rare little animal found digging in burrows exactly as the true moles of the insect-eating class of higher animals, but, like all the other members of the marsupial group, provided with the peculiar pouch for the young. This is the main characteristic. The females are all provided with a pouch, or fold, on the under side of the abdomen, in which the young immediately after birth are placed and retained until large enough to shift for themselves. The young marsupials are born at a much earlier age than in the case of the higher animals; hence this pouch is provided for their protection. When the young of the opossum become old enough to leave the pouch, they quite frequently run about the mother and take refuge in the pouch again on any alarm. In the kangaroo, the young animal remains in the pouch until grown to be quite large; and the adult kangaroo may frequently be seen grazing and the young in the pouch also sticking its head out, eating grass. In all the kangaroos, the hind feet are immensely developed for leaping and jumping; the tail also serves as a spring to assist in the jump; and the front legs are very short. The marsupial pouch is situated right between the hind legs. The marsupials are all confined to Australia, with the exception of the opossum, and these are found mainly in South America—one species only occurring (as far north as Long Island) in the United States. The opossum is largely arboreal and the tail is strictly prehensile, continually wrapping around the limb and assisting the animal in climbing; and the young animals frequently climb out from the pouch and wrap their little tails around the mother's tail to support themselves, as the mother goes from place to place.

Among the monodelphia (which includes all the other mammalia excepting the marsupials and duck-bills) the rodents (rats, mice, porcupines, rabbits, and all the other gnawing animals) probably present greater diversities than any of the other orders. Some are adapted to running; some burrow in the ground, after the fashion of moles; others, like the musk rat, are adapted to aquatic life; and still others, like the flying squirrels, are able to fly, in a limited fashion, in the air. The wing of the flying squirrel, is, of course, not a wing at all, but merely a fold of skin, alongside of the body, which, when the legs are stretched out, makes a short parachute, and the animal is able to sail down in a zigzag flight from the upper to the lower part of the tree, and then climbs up and sails down again.

It is possible to recognize the rodents immediately by examining the teeth. There is scarcely any difference in the structure of the teeth, and every one of the thousands of species of rodents that exist to-day has the same peculiarity; namely, there are no true canine teeth whatever. There is a large gap in the jaw between the incisors and molars, and, looking from in front directly inside of the animal's mouth, are seen only two large incisors above and two below, just as in the mouth of the rat.

The rabbit has two additional incisors which, instead of being visible from the front, are placed at the back and entirely concealed. The action of the animal in gnawing, by rubbing these two teeth together, always tends to wear off the surfaces; and if the teeth did not grow continuously they would soon be worn away down to the edge of the bone, quite useless; so that the teeth continue to grow out from the base, all the time; and in animals in which one of the lower teeth has been broken off accidentally and entirely lost, the upper tooth, having nothing to check the growth, grows all the way around in a circle and comes out of the mouth, making a complete ring.

The rodents are subdivided into two main sections: first of all, the rabbits, in which there are these little supplementary, incisor teeth, back of the larger ones; second, the mouse and squirrel series, in which there are only two incisors. The rabbits throughout the world are about alike in structure and are built on the same general plan as our common cotton tail rabbit in the East. There is only one species in the southeastern part of Pennsylvania, although the large hare enters the State near the mountains.

Marmots are really ground squirrels which have taken up the life on the ground entirely in preference to the trees; and our common ground hog of the East is the typical marmot, although quite a large species. It is found quite abundantly all over the hilly districts of eastern Pennsylvania, northward through New England and Canada, but not in the Southern States. There is one other group, including the beaver, which is quite a large rodent and is now well on the way to extinction in most parts of the country.

Among mice, the commonest are the two forms: the Norway rat and the house mice. We have the native rat known as the rock rat and various native mice—the commonest ones being the white-footed mouse and the jumping mouse and the vole, or field mouse. Our common mouse may be grouped into two sections: the mice and the voles—the mice being better runners and being found on the surface of the ground (quite frequently they have well developed ears and rather long tails); the voles are almost entirely burrowing animals, occurring just beneath the surface of the ground under the heavy mat of grass and having very short ears and very short tails. There are several genera of these voles which, externally, look remarkably alike. The common field mouse is one of them, and, closely allied to them, the pine mouse. A second group is the red backed mouse; and the third group, the lemming vole, which was never known south of New England until a few years ago, when another gentleman and myself discovered a species of them in the cranberry bogs in New Jersey.

The guinea pig and porcupine also belong to the gnawing animals. In our North American porcupine the hair is usually longer than the quills, which are quite short and strong.

The next species includes animals of carnivorous tendencies but of small size; the mole and the shrew; the common mole and the star-nosed moles and two shrews, one with its front legs developed into those flat, scraping, digging hands which we see in the mole; then one other typical mole, a very small animal, not longer than a man's forefinger, but having a very long tail.

The bat's forelimbs present the humerus bone; but the ulna, or forearm, is almost entirely wanting. The radius is very long and curved, the ulna being a short bone depending on the inner surface. As to the carpal bones, there are several small bones corresponding to the wrist; then a short thumb, with generally a hooked claw attached and four immensely long fingers—two of them joined close together and the other branched out; and between the tips of these fingers is the membranous structure by which the bat flies. It generally reaches alongside of the body and down along the hind feet; although the hind leg is not so modified as in the case of the fore leg, the hind leg being practically the same as in the small mouse. The toes are very short and project. In the red bat the membrane that stretches over the tail, between the hind legs, is covered with fur on the upper surface, just as the main covering of the bat. In all the other species the tail membrane is bare.

To the monodelphia also belong the various species of whales, the dolphins, and porpoises, all adapted entirely for aquatic life, with hinder limbs entirely abortive. Some of the whales are entirely devoid of teeth.

The group "manatee" includes only one animal which bears the group name and is somewhat allied to the whale, but in the character of its anatomy shows tendencies toward the next group, or elephants, certainly a much higher type than the whales themselves; and may be its aquatic life has produced the resemblance to the whales and it is really derived from a different stock.

The group "hyrax" includes the coney of South Africa, bearing a general resemblance to some of the rodents, but in the character of its skull and general anatomy entirely different and seemingly the type of a distinct group of animals of which this little animal is the only living representative. The general appearance of the skull of the hyrax is very much like that of the elephant.

The hoofed mammals are, next to the rodents, the largest mammalian group, and include the horse, cow, pig, giraffe, and all the various deer—the feet being adapted to life on the ground—to running and not to climbing. None of the forms are arboreal in any degree whatever. Hoofed animals are separable into two groups, according to the structure of the feet. In one group the horse is the type, that is, a group in which there is only a single toe, or in which there are three toes, as in the rhinoceros, with the middle toe the largest. The other group is known as the split hoofed and includes the deer, the ox, the sheep, and swine, in which there are two toes of equal size to support the body. The evolution of this single toe in the horse and the two-toed condition we find in the camel and in the deer is very interesting. The foot of the bear presents four toes of about equal size. The third, however, tends to be slightly larger than the others. In the rhinoceros is a little modification of that: one toe has been almost lost, represented merely by a little budding excrescence on the inside, and the middle toe is much larger than the other developed ones. In the horse, the single toe is very much enlarged and entirely supports the animal. In a series of fossil animals related to the horse it is possible to find all the forms corresponding to the present tapir and rhinoceros and all the other intervening forms showing first the loss of one toe and the reduction of a pair of toes, until we have nothing left but the little splints of the modern horse.

The pig has the side toes considerably shortened and the foot is mainly supported on the two middle ones. In the foot of the deer the shortened sides are still further reduced and are entirely useless, and the animal supported entirely on the middle toes, as in the cow. In the cow, the side toes have been lost altogether and the other one has been too. In all these animals, except the tapir, a line drawn in the center of the foot would pass through one toe; while in the tapir, the same line would pass between two; so that one kind is quite a solid hoofed and the other a split hoofed mammal.

In all the genera of deer and ox there is total absence of incisor teeth in the upper jaw, though well developed in the lower. That absence answers in these cattle, whose soft upper lip serves very well in grasping the grass and the lower incisors in biting it off.

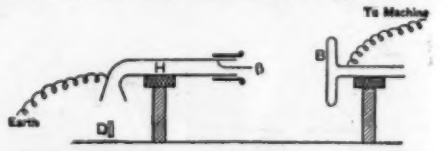
The carnivora or flesh-eating animals have the teeth very strong, being specially characterized by a great development of the canine, suitable for killing and tearing their food. The carnivora may be separated into land carnivora and another group including seals. Most persons would, offhand, place seals with the whales; but seals are merely modified dogs, or similar animals, and adapted to a life in the water. The skull of a seal is almost exactly like that of the dogs or bears. Seals, of course, have not lost their posterior limbs; but they are developed into paddles, the same as the anterior. Some of the seals are able to support themselves and clump about on land; and the walrus also has this ability; but others of the seals have the hind feet directed backward, used entirely as a rudder. They are quite unable to support themselves on land and cannot walk at all.

The carnivora that inhabit the land present several types: First, the bearlike carnivora, which walk on the whole foot, or are plantigrade; second, the doglike; and third, the catlike. The dogs and the cats walk on the tips of the toes—the heel elevated—and are known as digitigrade carnivora. Along with the bears go the weasels, otters, and all those small, slender, flesh-eating animals, including the skunk. With the dogs are associated the wolves and foxes. The third group, or cats, includes several varieties: in the first place, the group of hyenas, which are more or less connecting links between the dogs and the cats; then the civet cats and ichneumon, which are very slender animals resembling weasels and otters, but in the structure of the teeth closely allied to the cats; and lastly the true cats—the lions, tigers, wild cats, and domestic cats.

The monkeys, known as the primates, and culminating with man himself, include the highest developed mammals. The large apes show a tendency to the upright posture of man, frequently walking on their hind legs. The primates present two main divisions: first of all, the lemurs—very low monkeys—inhabiting Madagascar and the rest of Africa, living almost entirely in trees and having a very lowly developed brain, and in all respects are more allied to some of the lower quadrupeds, but, of course, belong to the group of monkeys. The second group includes the thin skulled monkeys and the apes. These include the marmosets found in South America and the southern part of Mexico, which latter limits the northern range of the monkeys in America. These include all the forms of monkeys with prehensile tails, grasping the limbs with their tails as well as the hands and feet; then the monkeys of the old world, which never have the prehensile tail, which member is sometimes very short, as in the baboons, and in others long and straight, but never used to wrap around branches; and the third group, highest of all, including the gibbons—various species of it—as the chimpanzee, gorilla, and orang-outang. The interesting feature in these large apes is that their feet are not yet developed in the same way as those of man. They are still entirely arboreal in their habits; and their feet are still adapted to grasping, with the thumb opposable to the forefinger; and when they walk on the ground they walk on the side of the foot. Instead of trying to plant the feet down, they walk on the back of the knuckles.

FLAME GASES AND ELECTRIC DISCHARGE.

IT has long been observed that high factory chimneys are comparatively little subject to damage by lightning. Whether that is due to the stream of hot gases and products of combustion usually ascending



from them is difficult to decide without certain test experiments. K. Wesendonck has made some interesting experiments which reproduce as closely as possible the conditions in question. *H* (see diagram) is a copper tube to which is attached inside a wire, *β*. Outside the end is a cylinder which prevents discharge from the tube direct. A burner, *D*, serves to introduce flame gases into the "chimney," *H*, and *β* represents a lightning rod. The thundercloud is represented by the brass plate, *B*, fed by an influence machine. On charging the latter negatively, a steady glow light will, under favorable conditions, proceed from the lightning rod. On lighting the burner, the glow is replaced by a brush or spark discharge. It is remarkable how sensitive the discharge is even to the presence of small quantities of products of combustion. After some working with a flame, it is impossible to restore the steady glow. The latter is also abolished by having gas jets burning in the room, and restored again by airing it. This is important to know, as it may explain the contradictory results obtained with spark discharges under apparently identical conditions. It seems pretty certain that flame gases are not the cause of the immunity of chimneys, though they be indirectly so by producing an ascending current of air.—Wesendonck, Wied. Ann., No. 7, 1898; The Electrician.

Every nation, whether Oriental or Occidental, has its own special methods of coaling, as of other occupations, but Japan supplies one of the most interesting examples of the differences which in matters of this kind distinguish the East from the West. The coaling of steamships at Nagasaki is done from lighters, and a series of elevated and inclined platforms that resemble a step ladder are affixed to the side of the vessel. They reach from the deck of the lighter to the main deck of the steamer or ship. The coal is handled in small baskets that will hold from 30 to 40 pounds. The coolies form in line on the ladderlike scaffold, and the baskets are quickly passed from one to another. The process resembles the old bucket brigade working on a roof fire. The coal passers work very quickly, and one gang of mixed coolies working from several lighters has been known to give a ship 437 tons in an hour. In the distribution of work among a gang of coolies, the woman is shown no favor. At the bottom of the line the first lift becomes longer as the coal recedes in the lighter, and at the top of the line the lift over the rail is hard, and the woman could be favored by placing her in the center. On the contrary, however, she is seen more often at the ends. The average rate of wages paid to women is about a shilling a day.

ENGINEERING NOTES.

The coal consumed in making scrap iron car axles at the Southern Pacific shops, as stated by Mr. D. Uren, before the Master Blacksmiths' Association, is 0·46 of a pound (bituminous) per pound of iron heated. The scrap is heated in four piles of 600 pounds each. These are roughed down the full length under the steam hammer, after which one-half of the axle is heated and finished and then the other half is treated likewise, three heats being required. The work is claimed to be improved enough by the heating to justify it.

It has often been noticed that the combustion of anthracite in the furnaces of steam boilers brings about the more or less rapid destruction of wrought iron tubes, owing to the action of the salts deposited upon them; and this tendeney to the deposit of a saline substance varies with the nature and source of the anthracite, observes the Eisen Zeitung, being considerable in that from the Kohlscheid district of the Wurm coal field, near Aachen, while British anthracite of good quality is much freer from this defect. With the object of ascertaining how this difficulty may be counteracted, trials were made of wrought iron tubes variously coated, and also with brass tubes like those of locomotives; but after a continuous trial of five months it was found that the coated iron tubes gave no better results than those uncoated. Galvanized wrought iron tubes appeared sound outside, but when they were examined inside it was found that the zinc had been dissolved, so that on the salt crust being removed the bare iron appeared. It therefore became evident that galvanized tubes would soon become as defective as the ungalvanized, and inasmuch as they cost twice as much as ordinary wrought iron tubes, they can only be economical if they last more than twice as long. Brass tubes were also attacked inside, but to a slighter extent, and they may be considered to last a certain number of years before requiring renewal. It appears from the foregoing that brass is the best metal for flue tubes when anthracite is burnt on the grate; but its first cost constitutes a drawback, and experiments are now being made with both nickel and aluminum tubes with furnaces fired with anthracites.

An official statement of the average daily consumption of water per capita in a number of the leading cities of England, including the average for the several water companies which supply London, is as follows:

	Gallons per head.
Grand Junc. (London)	55¼
Chelsea (London)	47
Southwark and Vauxhall (London)	45
Brighton	43
Plymouth	43
Hull	43
London (average)	41
Lambeth (London)	40
West Middlesex (London)	39
New River (London)	35½
Bradford	35
Leeds	35
East London (London)	34½
Preston	34
Kent (London)	33½
Liverpool	31½
Croydon	31
Manchester (average 27)	30
Halifax	29
Swansea	28
Blackburn	25
Bristol	23½
Bolton	23¼
Birmingham (average)	23
Huddersfield	23
Burnley	23
Oldham	22
Cardiff	22
Sheffield	21¾
Nottingham (average 17½)	19
Birkenhead	18
Leicester	18

—Municipal Engineering.

Number of Vessels in the United States Navy.—

REGULAR NAVY.

First class battleships	12
Second class battleship	1
Armored cruisers	2
Armored ram	1
Double turreted monitors	6
Iron single turret monitors	13
Steel single turret monitors	4
Protected cruisers	13
Protected cruisers sheathed with wood	2
Unprotected cruisers	3
Gunboats	9
Light draught gunboats	3
Composite gunboats	6
Training ship (Naval Academy)	1
Special class	2
Torpedo boat destroyers	16
Steel torpedo boats	35
Wood torpedo boat	1
Submarine torpedo boat	1
Iron cruising vessels	5
Wooden cruising vessels	8
Sailing vessels	6
Tugs	14
Wooden steam vessels unfit for sea service	11
Wooden sailing vessels unfit for sea service	6
Captured in Spanish-American war	8
Total number of vessels in Regular Navy	189

AUXILIARY NAVY.

Merchant vessels converted into auxiliary cruisers	11
Converted yachts	28
Converted tugs	27
Steamers converted into colliers	19
Special classes	17
Revenue cutters	15
Lighthouse tenders	4
United States Fish Commission	2
Total number of vessels in Auxiliary Navy	123

—Army and Navy Journal.

ELECTRICAL NOTES.

A telegraph line from Cairo to Cape Town, in Africa, is talked of, with Mr. Cecil Rhodes as chief promoter. The proposed route would be from Fort Salisbury to the Zambesi, near Tete; thence to Zomba and along the west coast of Lake Nyassa to Karonga and Lake Tanganyika. At the latter point it would be necessary to lay a cable to the head of the lake, or obtain the permission of Germany or the Congo State to run an overland line through that territory. A telegraph line is now said to extend as far north as Lake Tanganyika, and from Cairo south it almost reaches the site of old Khartoum, or the junction of the Nile and the Atbara.

The Swiss telegraph business is a branch of the Post, Telegraph, and Railway Department, and any post office will receive or deliver prepaid telegrams. At the end of 1896 the telegraph lines represented a length of 4,865 miles, and there were 252 telephone stations, with 6,150 miles of wire and 25,090 subscribers. Snowfall is very troublesome, and 35 per cent. of the wires are now underground. In 1896 the official balance sheet showed, for telegraphs, $562,780 received and $519,520 expended; for telephones, the statement was $866,700 received and $869,680 expended. On January 1, 1896, the telephone rates were reduced, with an increase of 4,555 subscribers; but the annual income was decreased $56,870. The unfavorable weather of 1896 also affected the summer business in telegrams; in the extent of 3·83 per cent. in internal, 0·04 per cent. in international, and 5 per cent. in through messages.

Electric governors for marine engines are now being tried by Italian engineers. In one form recently invented mercury is depended on for communicating the effects of the rising of the propeller out of the water. There are two mercury vessels communicating with each other. When the ship rolls and the propeller rises the mercury runs from the one vessel to the other and cuts out a number of resistances connected to contact pins which pass into the space above the mercury contained in the vessel near the bow of the ship. This causes the current round a pair of electromagnets to increase, and the valve, being under the control of the electromagnet, closes gradually. When the bow rises, the resistances are brought in again one by one and the circuit of another electromagnet is closed. This electromagnet also controls the valve and it is opened. When the keel is level, no current goes through the electromagnets.

This is the story of the unfortunate error of the sparrows of Kansas City, as related in the sprightly fashion of The Star, of that place: "It's the birds," exclaimed the unhappy electrician to the superintendent. For the fiftieth time a department of the great Swift packing house had been plunged into darkness by the failure of the electric lights, and for the tenth time the superintendent had called the electrician, Mr. Kobell, to time. "Birds—bosh!" retorted the superintendent. "It's a fact!" protested the electrician. "The confounded birds take the fuses between the binding posts for threads and try to grab them off for their nests. Every time they pounce on a wire they break the current." "Bosh!" repeated the superintendent. The electrician rushed out and returned with two limp sparrows. "Look at the blisters on this one's feet," he cried, "and this one's bill is melted off!" Sure enough, the sparrows were burned and blistered. Under the eaves of the building the thin lead fuses had proved a charnel place for birds. At length it was decided that fuse covers have their advantages.

The first theater in London to adopt electrical power to assist in the construction of elaborate scenes in the manner advocated by Mr. Edwin O. Sachs is the Theater Royal, Drury Lane. Mr. Sachs, who holds the commission, has been intrusted with the arrangement for moving some large sections of the stage floor—each measuring 40 by 7 feet—to any level above or below the footlights. Every movement is to be easily controllable from an ordinary switchboard. This improvement will be completed for the Christmas pantomime. The contractors are the proprietors of the Thames Ironworks, who are rapidly carrying out the plan under most difficult circumstances, for the whole of the heavy constructional work had to be erected while such an elaborate play as "The Great Ruby" was in rehearsal. The rehearsing was gone through on a temporary stage flooring. Shifts of men worked turn by turn day and night. The principle of the suspended electrical lift has been adopted, but in such a manner that the appliances will be a great improvement on what has been so far done on the Continent. The material is steel throughout, except for the stage floor proper. It is satisfactory to find that the so-called National Theater should have led the way in such an improvement, and credit is due to Mr. Arthur Collins and his co-directors for having met the conservatism and prejudice so common to the stage with innovations which are in keeping with this age of invention.

Some years ago Branly demonstrated before the French Academy that carefully cleaned disks of certain metals, when pressed upon a polished steel plate, offered a remarkable resistance to the passage of an electric current. Such metals were iron, aluminum, bismuth, lead; while copper, tin, brass, silver, of which the electrician makes habitual use, did not show any resistance to speak of. He has now repeated the experiments, piling upon one another many metal disks all over the same metal, and supported by a central rod which passes loosely through them. Some very curious observations have been made. With some metals, e. g., zinc, it made no difference whatever, or only a very slight difference, whether the 45 disks were very gently laid upon one another or whether they were dropped upon one another. With other metals, aluminum for instance, the resistance was in the first case 1·5 ohms; in the second, 40 ohms. When the same pile was built up again the next day, the tests gave resistance of 2·2 and 216 ohms. This latter resistance decreased slowly to 86 ohms within 24 hours, but the spark discharge of a radiator striking the pile at once reduced it to 0·5 ohm. Similar observations were made with iron and bismuth, and also with piles built up of alternating metals. One fancies that the air layer on the metal and oxidation must have something to do with the phenomena; but Branly himself says that the suggestion of imperfect contacts offers no real explanation.

SELECTED FORMULÆ.

Almond Cream.—Dieterich gives this formula:

Spermaceti	2	ounces.
White wax	2	"
Sweet almond oil	14	fl. ounces.
Water, distilled	7	"
Borax, powder	60	grains.
Coumarin	½	"
Oil of bergamot	24	drops.
Oil of rose	6	"
Oil of bitter almond	8	"
Tincture of ambergris	5	"

Melt the spermaceti and wax, add the sweet almond oil, then incorporate the water in which the borax has previously been dissolved, and finally add the oils of bergamot, rose, and bitter almond.

Here are some formulas for creams containing sweet almond oil in emulsion or saponaceous form:

1. Ointment of rose water	1	ounce.
Oil of sweet almonds	1	fl. ounce.
Glycerin	1	"
Boric acid	100	grains.
Solution of soda	2¼	fl. ounces.
Mucilage of quince seed	4	"
Water, enough to make	40	"
Oil of rose,		
Oil of bitter almonds, of each, sufficient to perfume.		

Heat the ointment, oil, and solution of soda together, stirring constantly until an emulsion or saponaceous mixture is formed. Then warm together the glycerin, acid, mucilage, and about 30 fluid ounces of water; mix with the emulsion, stir until cold and add the remainder of the water. Lastly, add the volatile oils.

The rose water ointment used should be the "cold cream" of the U. S. P.

2. Sweet almonds, blanched	5	ounces.
Castile soap, white	120	grains.
White wax	120	"
Spermaceti	120	"
Oil of bitter almonds	10	drops.
Oil of bergamot	20	"
Alcohol	6	fl. ounces.
Water	sufficient.	

Make an emulsion of the almonds with water so as to obtain 16 fluid ounces of product, straining through cotton which has previously been washed to remove starch. Dissolve the soap with the aid of heat in the necessary amount of water to form a liquid, add the wax and spermaceti, continue the heat until the latter is melted, transfer to a mortar, and incorporate the almond emulsion slowly with constant stirring until all has been added and a smooth cream has been formed. Finally, add the two volatile oils.

3. Spermaceti	240	grains.
White wax	120	"
Castile soap, white	120	"
Bitter almonds, blanched	5	ounces.
Alcohol	6	fl. ounces.
Oil of bitter almonds	10	drops.
Oil of bergamot	1	fl. drachm.
Water, distilled	16	fl. ounces.

Triturate the almonds with the water to a smooth paste, melt the spermaceti and wax by means of a water bath, mix the two intimately, slowly add the alcohol in which the oils have previously been dissolved, and finally strain through cheesecloth.—Pharm. Era.

Ginger Wine Extract—Ginger Wine—Ginger Ale.—

GINGER WINE EXTRACT.

Tincture of ginger (2 parts root to 8 of alcohol)	4	parts.
Tincture of capsicum	3	"
Tartaric acid	6	"
Caramel	15	"
Water	32	"

Mix and dissolve.

GINGER WINE.

Sugar	8	parts.
Water	20	"
Ginger wine extract	1	"

Boil the sugar and water together, filter through cotton, and when cold add the extract.

GINGER ALE.

Sugar	8	parts.
Water	48	"

Boil together, strain, and when cold, add 1 part of extract, and sufficient brewers' yeast (about 1 ounce to 3 gallons of sirup) to cause fermentation. Put in a warm place for 6 or 8 hours, then bottle each tightly, and tie down or wire corks.—National Druggist.

Labels for Bottles.—Horace Jervis describes a method of labeling bottles with a solution of sealing wax, recommended by him in Chemical News, lxxvii., 133. The solution is made by grinding sealing wax first in the dry state, and then with a small quantity of a mixture of alcohol and ether in such proportions as to make a thick liquid. Instead of lettering with a stiff brush, as suggested in the original paper, it is better to use a piece of glass tubing drawn out at one end. This gives the letters a beaded appearance. When the above solution is partially evaporated and somewhat thickened, a rubber tube joining the pen and the lips enables the solution to be forced out as required. In this way one can letter as well as with pen and ink. The wax is not brittle when dry, and forms a durable and ready means of lettering the backs of note books. It may be used also for such purposes as waxing the calcium chloride tubes of Geissler potash bulbs, where heating tends to fracture the ground glass joint. Such articles should then be dried in a water oven.—Chem. News.

Label Paste.—A series of experiments conducted by Frank Edel, of Des Moines, Ia., and communicated to The American Druggist of June, went to show that a paste made after the subjoined formula was all that could be desired in the way of adhesiveness, keeping properties, and appearance. The formula:

White dextrin	5	lb.
Water, heated to about 160°	1	gallon.
Oil wintergreen	½	drachm.
Oil cloves	½	"

Dissolve the dextrin in the hot water by stirring; when cool add the oils and stir. Then pour the paste into suitable receptacles, glass, wide-mouth bottles or porcelain jars, cork and place in a cool place where the paste may congeal and ripen. The ripening process takes about one week.

THE STOMACH AND THE PHONENDOSCOPE.

THE Bianchi phonendoscope, which has already been described in these pages, is an excellent amplifying stethoscope, the small cavity of which, formed in a thick disk of metal, collects and transmits the slightest sounds without their character being changed by accessory noises or by resonances, as it is liable to be in stethoscopes having thin and light walls. It is owing to this instrument that Dr. Bianchi has been able to render practical his method of exploring internal

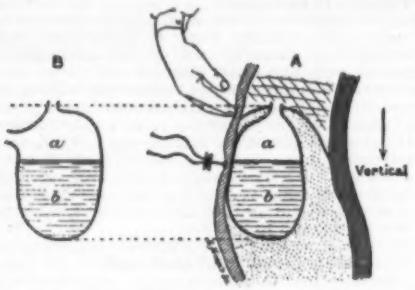


FIG. 1.—*A*, section of the stomach in its vertical position; *B*, phonendoscopic projection of the stomach; *a*, air chamber; *b*, liquid.

organs, an operation that he had previously been able to perform only with microphones that were too delicate to be removed from the laboratory and to be employed in clinics.

The exploration of the internal organs in order to determine, despite superpositions, their form and position in the living being, by combining percussion and auscultation, had been tried for a long time in different countries, but did not become really practical until it occurred to Dr. Bianchi to substitute for the vibrations caused by tapping with the finger those produced by the pressure and friction of the skin with the pulp of

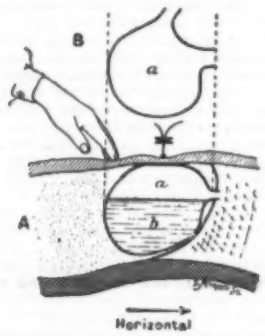


FIG. 2.—*A*, section of the stomach in a horizontal position; *B*, phonendoscopic projection; *a*, air chamber; *b*, liquid.

the finger. The vibrations caused in this way have but a feeble power of diffusion, and it is possible for the ear plainly to detect only those produced within the area of the organ with which one is in communication through the intermedium of the phonendoscope.

In the study of the stomach the phonendoscope has a fine field of research, for up to the present this organ has almost completely escaped any serious examination, notwithstanding the most ingenious methods that have been devised for the purpose. Neither internal lighting with an incandescent lamp or the X rays nor simple percussion has permitted of determining its exact position in the living being and the modifications that it undergoes in its form as a consequence of the ingestion of food. Moreover, in most cases, the exploration has been effected under adverse conditions, the individual under experiment having been made to lie upon the back. Now, in this position, as proved by the diagrams in Figs. 1 and 2, the contents of the stomach are attracted by gravity into the dorsal region, and the distorted organ presents upon examination but a feeble part of its real surface.

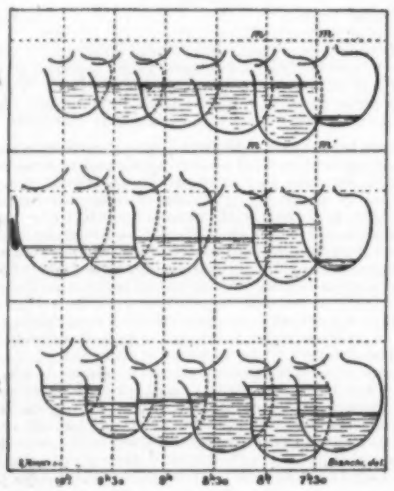


FIG. 3.—Successive Outline Drawings of the Stomach, showing the Modifications in Form caused by the Ingestion of Liquids. *A*, wine; *B*, bouillon; *C*, maté; *m m'*, median line.

In order to obtain an idea in regard to the operation of the stomach, it is necessary to determine the exact position of this organ in the living being (Fig. 4), the individual varieties, the changes that it undergoes in its form and position when it is loaded with food, the speed with which the latter passes into the intestine, according to its nature and that of the individual, and the consequences of such displacements of the organ. These different questions have been the object of Dr. Bianchi's studies for several years past, and the results of his researches have been published in the proceedings of several societies and in some of the medical journals.

In one series of experiments Dr. Bianchi studied the length of time in which alimentary liquids remain in the stomach. His method consists in drawing in the morning an outline of the stomach of an individual who has fasted, and then, after administering to him a pint of some liquid, such as coffee, wine, bouillon, or beer, making another drawing, and so on, every quarter of an hour for ten hours. The successive drawings

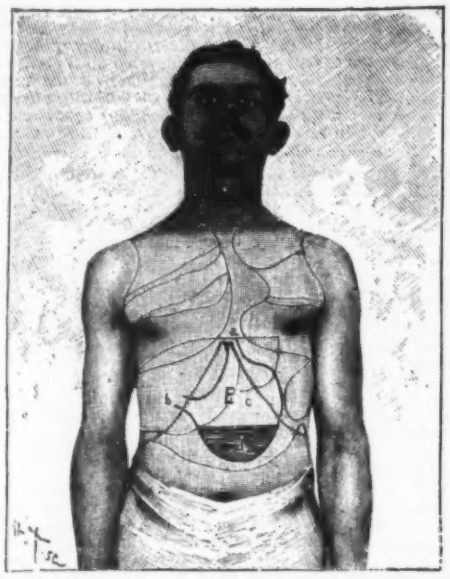


FIG. 4.—Phonendoscopic Projection of a Stomach, *E*, upon a Subject. *a*, cardia; *b*, pylorus; *c*, air chamber; *d*, liquid. The dotted line shows the border of the thoracic cage.

thus made permit of following the displacements of the stomach and the progressive evacuation of the liquid absorbed.

In a normal subject, liquids do not pass directly from the œsophagus into the intestine, as has usually been supposed, but always remain for a certain length of time in the stomach, and in most cases for two hours. It is through a series of rhythmic contractions that the stomach raises the level of its contents up to the pylorus and expels a portion thereof into the intestine.

Pure wine (Fig. 3, *A*), as a general thing, remains in the stomach but a short time. It quickens the movements of it, with the result that there supervenes a sensation of hunger, due probably to the fact that the organ continues to contract in an empty state.

With bouillon (Fig. 3, *B*) the effect is very different. A fermentation with an abundant production of gas soon occurs, the stomach distends, and the individual experiences a sensation of fullness, whence he concludes that he is satiated and that it is not necessary to eat any other food. It is doubtless this sensation of repletion that causes people to attribute to bouillon a nutritive value that laboratory experiments have never been able to demonstrate.

The presence of gas in the stomach greatly interferes with the expulsion of the liquids contained therein, as the gastric contractions do not succeed in raising the level of the liquid up to the pylorus, and the latter does not allow the gases to pass easily.

The effects of tea are very variable. Strong tea, especially when it is very rich in astringent principles, seems to cause an occlusion of the pylorus, thus interfering with the evacuation of the stomach, while weak tea hastens such evacuation.

One of the best stimulants of stomach contractions appears to be maté, or Paraguay tea, which, containing but little tannin, does not possess the inconveniences of tea, even when the infusion is concentrated. In one case the demonstration of its effect was very evident. The subject under experiment had eaten a great deal on the preceding day, his digestion was effected under adverse conditions, and when the first drawing was made (Fig. 3, *C*) it was found that the stomach, instead of being, as usual, nearly empty, was distended and contained a large quantity of liquid. Nevertheless, after the ingestion of 500 grammes of maté, the organ became empty quite quickly, more quickly even than after the ingestion of an analogous quantity of pure water.

The results vary greatly from one individual to another, and Dr. Bianchi has been enabled to demonstrate that such variations depend in most cases upon a difference in the position of the pylorus with respect

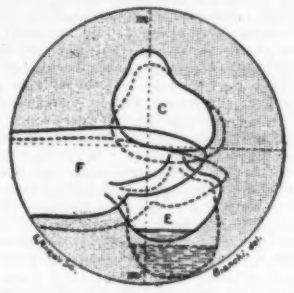


FIG. 8.—Displacement of the heart, *C*, and of the liver, *F*, through the ingestion of liquid into the stomach, *E*. *m m'*, median line.

to the cardia. It can be readily perceived that, if the exit orifice is superelevated, an evacuation cannot readily take place, while it may be facilitated in the contrary case.

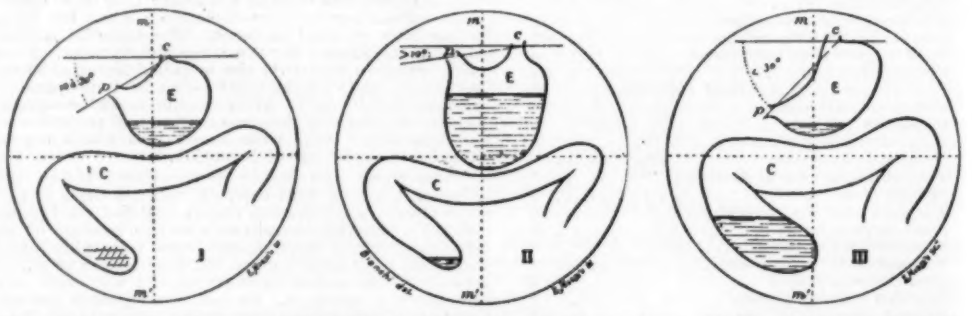
Such considerations have led Dr. Bianchi to establish three types of stomach (Figs. 5, 6, and 7), according to the obliquity with respect to the horizontal of the line connecting the cardia with the pylorus. Without entering into details as to the cause of such differences or as to the deductions that should be drawn therefrom from the viewpoint of the regimen to be followed, it suffices to point out that alongside of the normal type, in which the inclination of the cardio-pylorie line varies from 10 to 30 degrees, we find on the one hand the type of superelevated pylorus which is condemned to dilatation, and, on the other, the opposite type with a cardio-pylorie line approaching the vertical, and which, disburdening itself of its functions upon the intestine, sooner or later fatigues this organ.

In certain individuals it has been possible to discover a most curious fact, and that is that when the stomach does not retain liquids, and milk even has not time to coagulate therein, the cæcum is led to play the part of a supplementary stomach. In such persons, the right iliac fossa is distended, and, at first sight, it might be thought that there was a hernia in this region.

Many other researches upon the stomach have been made by Dr. Bianchi, who has succeeded in interpreting the motions of this organ, as well as the length of time that food remains therein, by ingenious diagrams, a detailed description of which would take up too much space.

It is well to allude, however, to a series of studies upon the modifications in position of the different viscera in the vicinity of the stomach—displacements that would have to be taken account of in clinics, and in fact, whenever an investigation of these organs is undertaken (Fig. 8).

For the above particulars and the illustrations we are indebted to La Nature.



FIGS. 5, 6, AND 7.—Diagrams of Three Types of Stomach. I. Normal type. II. Type with superelevated pylorus or depressed cardia. III. Type with depressed pylorus or superelevated cardia. *m m'*, median line; *E*, stomach; *c*, cardia; *p*, pylorus; *C*, colon.

THE PREVENTION OF CAMP DISEASES.

PLUTARCH states that Cyrus always carried with him water of a certain spring, which he drank from a golden vessel after having it boiled. This naturally suggests that not only were the huge armies which this monarch commanded subject to diseases incident to the use of impure water, but that the sanitary science of the day had reached a much higher state of development than is commonly accredited to it. Certain it is that, could the soldier be induced to adopt a precaution much less onerous than that taken by Cyrus—i. e., the boiling or filtering of any apparently clean water—typhoid would practically disappear from the army.

The typhoid fever from which the army has suffered in all its large camps was taken into the systems of the soldiers with the drinking water. On this point there can be no doubt, though in individual instances the disease may have been contracted from milk as an indirect water contamination, or among doctors and hospital attendants from neglect to disinfect the hands after handling patients afflicted with the disease.

No bacteriological or chemical examination can prove the purity of water in so far as the typhoid infection is concerned, and it is safe to say that no spring or well within an area of five miles of a camp in which typhoid is endemic should be trusted twenty-four hours after such a camp has been pitched. The means of con-

tamination and the probability of its occurring are so obvious as to require no detailed mention.

As long as the sanitary inspectors of camps hold that the water supplied to the men is pure and safe because, for instance, it comes from an area in which there are no houses, and hence should be pure, typhoid once started in camp will spread.

All water should be regarded as dangerous until it is either boiled or filtered; in this belief the soldier should be trained. Boiling is troublesome, often impossible. Filtering is easily accomplished and is always practicable during periods of encampment. When there are many troops assembled in one camp, and the water is piped to the various regiments, the government could and should establish such a system of sedimentation and sand filtration as has been shown to be an efficient remedy against typhoid. When this is not practicable, there are small filters which render the water absolutely sterile and which, if issued to each company together with a barrel or other reservoir for storage, would, at the expense of one man's attention, secure an abundant supply of absolutely wholesome water. These filters could also be carried on the march, and during rest periods could render safe the supply from neighboring springs.

The first step toward crushing out the present epidemic of typhoid and toward preventing a recurrence of the disease with each large encampment is absolutely to distrust the drinking water and to subject all of it to a sterilizing process.

As an occasional means of typhoid infection, perhaps even a frequent means, when there are many walking about with latent forms of the fever, may be mentioned the flies, which in Tampa swarmed over everything. The immediate and habitual covering of all dejecta with earth tended to lessen if not entirely to abolish this danger.

Gastro-enteritis—though perhaps this is a misnomer for the anorexia, cramps, and diarrhea which constitute the commonest forms of sickness to which the soldier is subject—is usually directly traceable to drinking, while hot and tired, large quantities of cold liquid, often beer, to eating ill-cooked or ill-chosen rations, including under this caption raw fruit, to sudden chilling of the surface.

The regimental canteen has proved a distinctly crippling factor in Southern camps, though its action in Western posts may, as has been claimed, be beneficent. It, together with every saloon and soft drink shop within reach of the army, should be closed to the soldier, and the pay-day drunk, diverting in itself, but a good feeder to the sick call, would then be abolished.

The food which the men receive should be inspected by the officers, particularly the company officers and those of the medical staff. It is probable that as the volunteer army now stands not one company cook out of five had any experience in the culinary art previous to the breaking out of this war, and that not one out of eight could on his present merits preside over the kitchen of a third class eating house. It might be a serviceable reform to have the officers' tables served from the company messes; it certainly would be a great help to have the cooks regularly and carefully instructed in the rudiments of their art.

Raw fruit, even when fresh and ripe, is like beer, so fermentable and so likely to cause diarrhea, that its consumption should be avoided.

As to the avoidance of surface chilling, the belly-band, which promised much, has, as a rule, not proved its claims. Some oversight on the part of the company officers would accomplish much in this direction.

It is of cardinal importance that we should clearly realize that the means by which most of the camp diseases may be avoided are well understood and are so simple and practicable that they may be efficiently carried out, provided a sufficient amount of energy is displayed by the company officers and by the regimental doctors.—Therapeutic Gazette.

SUPERFICIAL TENSION AND CAPILLARY PHENOMENA.

WE propose in what follows to pass rapidly in review the principal consequences of the existence of superficial tension.

The first of these is as follows: When we pass from the convex to the concave side of the surface of separation of two fluids there is an abrupt increase of what has been called "capillary pressure." Laplace has given a formula that permits of calculating such pressure, and the consequences of such formula are quite unexpected.

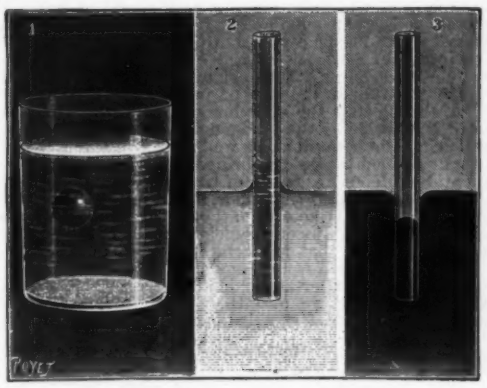
The form of equilibrium of a small drop of a liquid isolated in the midst of another liquid that has the same density as itself, and that consequently withdraws it from the action of gravity, must be that of a sphere. This is a fact easily verified by carefully placing a drop of oil in a mixture of alcohol and water having the same density as the oil (Fig. 1).

2. The form of equilibrium of a certain mass of a fluid isolated in the midst of another fluid must also be that of a sphere. It is for that reason that soap bubbles are spherical, and doubtless also that the sun, moon, and planets are spherical. If now, passing to another order of ideas, we seek the condition of equilibrium of two liquids and a gas, or of a solid, a liquid, and a gas in contact, in taking account of the existence of superficial tensions, we may find through calculation the size of the junction angle. There are cases in which such equilibrium is impossible; for example, when oil is poured upon water in contact with the air. The oil cannot take on a form of equilibrium, but spreads out over the water as far as possible and forms upon its surface an exceedingly thin film that reflects the brightest colors. Moreover, in the present case, from the very fact of the replacing of the surface of water-air separation by the surface of oil-air separation, there results quite a notable diminution of potential energy. It is upon this latter point that is based the practice of spreading oil over water to calm the waves.

From a knowledge of the angle of junction of a liquid and a solid, we may conclude the form that must be exhibited by the free surface of a liquid in equilibrium. It is thus that is explained the ascent of water in narrow tubes, with the formation of a concave meniscus, and the depression of mercury, with the formation of a convex meniscus. This is shown in Figs. 2 and 3, in which the diameters of the tubes and the curves are purposely exaggerated.

The form of these menisci permits of explaining why it is that small bodies floating upon the surface of a liquid attract each other and unite if they are all wet or not wet by the latter, while two bodies, one of which is wet and the other dry, repel each other. The experiment may be easily tried by means of clean corks and corks covered with lampblack placed upon the surface of water contained in a wide vessel.

The variation of the junction angle on the contact of a liquid and a tube imperfectly wet permits of obtaining what are known as capillary strings of beads. These, in consequence of the variations in pressure that occur at every liquid curve, are exceedingly rebellious to motion and may even (if the tube is constricted here and there) form a hermetical stopper. We know that if we blow air into the veins or arteries of an animal, the latter will be fatally doomed to die; and this is precisely because in the blood vessels we have formed



EXPERIMENT ON SUPERFICIAL TENSION AND CAPILLARY PHENOMENA.

capillary beads that resist motion and therefore arrest the circulation of the blood.

Finally, under various influences, the superficial tension of a liquid is capable of becoming modified, and various consequences may result therefrom. Thus, for example, wine exposed to the free air loses alcohol through evaporation, and its superficial tension increases, especially in the vicinity of the edges of the containing vessel. Then the alcoholic liquid ascends along the walls, mixes with the less alcoholic liquid that is in contact with them, and afterward falls back to the bottom of the vessel.

So, too, as the superficial tension diminishes when the temperature rises, we may, in order to remove a grease spot from cloth, cover one of the edges of the spot with blotting paper and apply a hot iron to the other edge, whereupon the grease will reach the cold edge of the blotting paper.—J. Derome, in La Nature.

SPONTANEOUS ANALYSIS OF GUNPOWDER.

MR. GILLAN, preparator at the Paris Museum of Natural History, has pointed out to us a very singular method of separating the products composing gunpowder. A small quantity of this substance had been left at the bottom of a glass containing water that sat near an open window, where it underwent the ac-

SPONTANEOUS ANALYSIS OF GUNPOWDER.

tion of cold at night and the heat of the sun in the daytime.

Some time afterward, when it occurred to Mr. Gillan to throw the powder away, he was surprised to see the rim of the glass covered with a deposit formed of crystalline elements whose whiteness contrasted singularly with the blackish deposit left at the bottom of the glass, the water having entirely disappeared. The nitrate of potash (or saltpeter) had separated from the charcoal and sulphur and crystallized at the top of the glass.—La Physique Sans Appareil.

A French contemporary, Cosmos, publishes a table showing the number of patents granted in each country up to the end of 1897. According to this there have been over 1,729,000 patents issued, of which 606,423 were granted in the United States, showing that more than one-third of all the patents taken out were American.

A TABLE OF ATOMIC WEIGHTS.[1]

By THEODORE WILLIAM RICHARDS.

SINCE no natural constants are more used by chemists than the atomic weights, it is a matter of great importance for every one, from the chemical philosopher to the practical analyst, to have a convenient table of them always at hand. Unfortunately, the present state of our science makes the selection of the values often a matter of personal opinion; and because this is the case, it is well that many of those who have had experience in accurate quantitative analysis should express their views. Hence arose the present work, which was begun solely for use in Harvard College.

It is true that an accurate table of atomic weights may sometimes be less appropriate for the calculation of analyses than an inaccurate one, for the constant errors of any one process are eliminated as much as possible from the accurate table, and, moreover, all the results are reduced to the vacuum standard. Of course, neither of these refinements is to be expected in common work, although many uncorrected methods may yield results which are very consistent among themselves. Obviously the best table for the practical calculation of analyses would be a list of factors, in which each quantity had been found empirically according to precisely the method which is to be employed in the analysis of an unknown substance.[2] Since, however, the errors of ordinary work often eliminate one another, and since such a table of empirical factors would have to be accompanied by exceedingly minute directions, the scientifically accurate table of atomic weights is generally the most convenient substitute for the factors demanded by the analyst, as well as the most suitable basis for theoretical considerations concerning the periodic system of the element.

In the compilation of the following table the chief emphasis has been laid on the probable chemical accuracy of the processes involved in each case. The search for possible causes of constant chemical error has usually furnished the evidence, if any evidence was to be obtained, upon which has been based the sometimes very puzzling decisions between conflicting data. For example, the possible occlusion of foreign matters by many precipitates has always been borne in mind, as well as the fact that crystals obtained from aqueous solutions usually retain with great obstinacy important amounts of mother liquor inclosed within their structure. Oxides and other substances obtained by ignition often have a tendency to occlude traces of other materials remaining from their mother compound; of course, the possibilities of such a serious error must be carefully weighed in each case. Most experimenters upon the volumetric ratio of silver to the chlorides have produced erroneous data, through lack of knowledge of the dangers of this apparently simple process. These results must then be given small weight, no matter how concordant they may seem. The solubility of glass and porcelain, as well as nearly all precipitates, is another frequently overlooked source of grave complications, and so is the action of many substances upon their containing vessels at high temperatures. The fact that in some cases the necessary methods of calculation greatly magnify the experimental error was not forgotten.

These and many other equally obvious minor principles have served as the guides in the selection of the figures below; but, of course, the results cannot be considered ultimate. "Post-mortem examinations are often unable to detect the more subtle poisons." In many cases much more experimental work is needed, not only to secure new data, but also to show where the old are in error. While, however, it is very important to show such falsity, the attempt to counteract it numerically by the application of small corrections is a dangerous remedy; for minor conditions often seriously modify the minor corrections. In such cases wholly new data must usually be obtained, and these must be corrected, if correction is necessary, by him who is familiar with every step of the processes involved.

One is continually reminded as he studies the conflicting evidence of the words of Ostwald: "Differenzen sind nicht selten, und mahnen ernstlich an die Unvollkommenheit menschlicher Arbeit, aber auch an die Verantwortung, welche jeder übernimmt, welcher einen numerischen Wert der Oeffentlichkeit mitteilt."[3] This responsibility is not always realized by eager investigators, who seek to make up for a possible lack of quality by a superabundance of quantity. "A single determination well worked out is better than twenty incomplete ones. Too much cannot be said against the multiplication of incomplete or carelessly obtained data; for such data carry with them not only uncertainty and confusion in the present, but also additional labor for a reviser in the future."[4] Every reaction must be assumed to involve some constant error, and every substance must be assumed to contain some constant impurity, until a proof of the contrary is obtained. Our wofully discordant data furnish a heavy presumption against almost any chemical method when greater accuracy than one part in four or five hundred is desired.

The standard O = 16.000 is adopted below, as likely to be the most convenient for many years to come.[5] The last figure of each number given in the following table cannot be considered in any case certain. It is often probably not much more than one unit in error, although the uncertainty may amount to as much as six or eight units in some cases. Of course, the decimal notation does not admit of closer indications without an individual explanation in each case. For example, iron, germanium, and gallium are given in the table as 56·0, 70·0, and 72·5 respectively. The first is probably known within 0·1 or 0·2, while the other two may easily be 0·5 in error; but the method of expressing the results does not admit of this grade of distinction.

The aim has been to construct a convenient working table, which shall carry with it all that is trustworthy and nothing that is unnecessary. It is almost needless to state that the well known standard works of Clarke, Meyer, and Seubert, Ostwald, Van der Plaats, and

[1] Presented to the American Academy of Arts and Sciences, March 9, 1898. From The American Journal of Chemistry.

[2] Compare Seubert: Ber. d. chem. Ges., 21, 2180.

[3] Ztschr. phys. Chem., 3, 143.

[4] Proceedings Amer. Acad., 31, 99; 36, 294.

[5] Compare F. W. Küster: Ztschr. anorg. Chem., 14, 251.

others have been freely consulted in the preparation of this table, as well as many of the original papers.

Especially am I indebted to Prof. Clarke for his latest gigantic collection of data and results,[1] which would have made the present table a work of supererogation, if he had viewed the subject from a somewhat less mathematical standpoint. Prof. Clarke's method of decision places the credit with the skillful manipulator; I have striven to give the thoughtful chemist who is not so clever with his hands the credit which I think belongs to him. The fact that the two tables usually agree is due either to the best methods having fallen into the best hands, or to Prof. Clarke's having wisely forsaken the rigid application of his principle, or else, especially in the case of the rare metals, to the lack of data affording room for intelligent difference of opinion. Among the seventy-four atomic weights given in the table only seven differ enough from the values computed by Clarke to excite remark. It seems fitting to give a brief statement of the reasons for the differences in those seven cases, leaving the details of reasoning about the other sixty-seven elements unpublished. The elements mentioned are antimony, cadmium, calcium, magnesium, platinum, tungsten, and uranium.

It is not my purpose to enter at length into the discussion of the antimony problem. Much of the voluminous work upon this subject is now rejected by common consent. The work of Bongartz,[2] sometimes accepted as the best, because it is the most recent, has the grave faults inherent in all methods which involve the precipitation of baric sulphate. Among all the published data Cooke's analyses of antimonious bromide[3] (Sb = 119·92) seem to me the most satisfactory, because of the admirable fitness of argentic bromide for quantitative work, and because of the many precautions used in both preparation and analysis. Cooke's[3] and Schneider's[4] work upon the sulphide (Sb = 120·5) are, perhaps, the next in order; but Cooke's work upon this subject was far less satisfactory than his work on the bromide. Accordingly, the value 120·0 is given as the atomic weight of antimony in the accompanying table, instead of 120·43, computed by Clarke.

Although the atomic weight of cadmium has been the subject of many investigations, it is still far from certainly established. Many reasons combine to make me think that the highest of the published values are the most accurate. Dumas'[5] work upon the chloride of cadmium led to the value 112·23; but his method of investigating chlorides sometimes gave him too low results.[6] V. Hauer[7] and Partridge[8] found cadmium equal to less than 112 by heating cadmic sulphate in a stream of hydric sulphide, but there is no proof that their initial substance was thoroughly dried. On the other hand, Bucher's conversion of cadmic sulphate into the oxide led to the value 112·36, which Bucher regards as the minimum.[9] This method is one in which the tendency of the oxide to retain sulphuric acid is approximately neutralized by the tendency of the sulphate to retain water; this fact is demonstrated by Baubigny's[10] good results on zinc, nickel, and aluminum, as well as Marignac's[11] on magnesium. The results of Lenssen,[12] Partridge, Morse and Jones,[13] and Bucher, involving the use of cadmic oxalate, all in the neighborhood of 112, are likely to be too low because of the great difficulty of freeing this substance from water. Morse and Jones have clearly indicated this and other possible causes of error. Moreover, I doubt very much if it is possible to prepare the oxalate free from the nitrate by precipitation from solutions containing cadmic nitrate. The method of calculation magnifies either error by introducing it in opposite directions into the numerator and denominator. Bucher's extended work casts grave doubts upon cadmic oxide (used by Morse and Jones, and Lorimer and Smith)[14] as a suitable substance to serve for a basis of operations. On the other hand, the work of Huntington[15] and Bucher with a bromide (a very satisfactory substance as to its preparation because it may be sublimed, and as to its analysis because of the insolubility of argentic bromide), and that of Bucher with cadmic chloride, point toward 112·3 or 112·4 as the probable figure. The electrolytic work of Hardin[16] upon these compounds, performed unfortunately with small amounts of material, is, nevertheless, in favor of the lower value, 112·0, so that any value adopted must be uncertain. Clarke computes 111·95; for the following table, 112·3 has been chosen.

There is good reason for believing that Clarke's value for calcium (40·07) is probably too high. The only determinations worth considering are those of Erdmann and Marchand upon the composition of Iceland spar, and only one out of their thirteen experiments is corrected for known causes of constant error.[17] This experiment, which really constitutes the sum and substance of our pseudo-accurate knowledge of a very important quantity, makes calcium almost exactly 40·0. Obviously but little confidence may be placed in such meager material; it is surprising enough that so common an element has remained forty years untouched on so unsatisfactory a basis. An extended investigation, now well advanced in this laboratory, has as its object the securing of less impeachable data upon the atomic weight of this frequently appearing constituent of the universe.

Marignac's[18] results from the quantitative ignition and synthesis of magnesic sulphate, processes in which the constant errors are likely to eliminate one another, have been so completely confirmed by the recent work of Richards and Parker,[1] that magnesium is represented by the figure 24·36 in the table. The results of the syntheses of magnesic oxide by Burton and Vorce[2] have been shown by Richards and Rogers[3] to be under the cloud of a serious possible constant error, and no other results offer weighty evidence against the value just named.

An important deviation from the usually accepted figures is to be seen in the value assigned to platinum below. Our knowledge of the atomic weight of this element depends chiefly upon the elaborate and carefully executed work of Seubert[4] and Halberstadt,[5] and the only question is how this is to be interpreted. These chemists studied the platin-chlorides and platin-bromides of potassium and the platin-chloride of ammonium, weighing these compounds and some of the products of their decomposition. The careful study of the results shows at once that some source of error lies hidden in all the data, for the various ratios are not wholly consistent, even in any one series. Any value from 194·7 to 196·0 may be obtained from the figures,[6] the results of Seubert's work being the least discordant among themselves. Dittmar and M'Arthur[7] explain the discrepancy in the case of potassic platin-chloride by assuming that the complex salt contains traces of hydroxyl replacing the halogen and traces of hydrogen replacing the potassium, as well as a small amount of extra occluded potassic chloride. They adduce experimental evidence in proof of this view, but Seubert showed in his reply[8] that their hypotheses can hardly be applied to his determinations. Most of Seubert's and Halberstadt's inconsistencies may be explained by the supposition that the complex salts, like all substances crystallized from aqueous solution, contain certain traces of mother-liquor held in minute cells within the crystal structure, and that these traces of water are not free until the substance is disintegrated. I have accumulated a large amount of experimental evidence, soon to be published, upon this subject. Water is one of the most dangerous, although one of the least heeded, impurities in this kind of work; and in my opinion it is responsible for the lack of agreement in this case. Hence the best data for the calculation of the atomic weight of platinum seem to be those concerning the relation of the metallic platinum to the potassic chloride or potassic bromide formed by the decomposition of the complex salts, for the water must surely have been expelled from these products of the ignition. According to Clarke[9] potassic platin-chloride yields 40·101 per cent. of platinum and 30·671 per cent. of potassic chloride—the means of the closely agreeing results of Seubert and Halberstadt—while according to Halberstadt potassic platin-bromide yields 25·915 per cent. of platinum and 31·591 per cent. of potassic bromide. Disregarding the weight of the complex salt, and assuming that KCl = 74·595 and KBr = 119·095, it is easy to calculate the respective values 195·06 and 195·39 for platinum. The mean of these two values, 195·2, is given below, instead of Clarke's 194·89. The possible occlusion of potassic halide by the complex salt may render even 195·2 too low; but more investigation is evidently needed to prove this.

The same errors may enter into the work on other platinum metals, indeed Seubert[10] admits that traces of water were contained in some of his salts, but he applies no correction for this serious cause of inaccuracy. Since, however, Clarke's method of combining the discordant results seems more nearly to eliminate the error in these cases, his values for these elements are but little changed in the following table.

Feeling wholly unable to decide the present controversy between the two conflicting values (184·9 and 184·0) now proposed for tungsten, I have chosen the mean 184·4 as a compromise which cannot be much more than 0·3 per cent. out of the way.[11]

Uranium, the highest of all the atomic weights, is one of the least satisfactorily determined. Recent investigation upon this subject at Harvard seems to show that all the published data are complicated by constant errors, which, however, sometimes partly eliminate one another; accordingly the round number 240, instead of Clarke's 239·59, is printed in the table. The discussion is better deferred until our work has taken more definite shape.

Besides these seven elements, there are seventeen more whose atomic weights, as given in the following table, differ from the results of Prof. Clarke's computations by one part in a thousand or more. As none of the seventeen values is known certainly to within one part in five hundred, and some of them are probably at least as much as one per cent. in error, differences in these cases will excite no especial remark. The elements are cerium, columbium, erbium, gadolinium, gallium, glucinum, indium, lanthanum, neodymium,[1]

[1] Since the publication of this paper in the Proceedings of the American Academy, H. C. Jones has published a research upon the "dymia" which far exceeds in accuracy and completeness the vague statements of their first separator. Oddly enough the new values are the old ones interchanged. While it is impossible to say how nearly the new figures represent the peculiarly elusive values in question, they carry with them much greater weight than the old ones, and are given, as far as the first decimal place, in the table. See this volume, p. 345. The value 142 for the mixture "didymium" is also given for convenience in the calculation of analyses in which it is not possible to separate the twins.

A TABLE OF ATOMIC WEIGHTS OF SEVENTY-FOUR ELEMENTS.

Compiled in March, 1898, from the most recent data.

Name.	Symbol.	Atomic Weight.
Aluminium	Al	27·1
Antimony	Sb	120·0
Argon	A	39·9 ?
Arsenic	As	75·0
Barium	Ba	137·43
Beryllium	Be = Gl	9·1
Bismuth	Bi	208·0
Boron	B	10 95
Bromine	Br	79·955
Cadmium	Cd	112·3
Caesium	Cs	132·9
Calcium	Ca	40·0
Carbon	C	12·001
Cerium	Ce	140·0
Chlorine	Cl	35·455
Chromium	Cr	52·14
Cobalt	Co	59·00
Columbium	Cb = Nb	94 0
Copper	Cu	63·60
"Didymium"	Nd + Pr	142 ±
Erbium	Er	166·0
Fluorine	F	19·05
Gadolinium	Gd	156·0 ?
Gallium	Ga	70·0
Germanium	Ge	72·5
Glucinum	Gl = Be	9·1
Gold	Au	197 3
Helium	He	4·0 ?
Hydrogen	H	1·0075
Indium	In	114·0
Iodine	I	126·85
Iridium	Ir	193·0
Iron	Fe	56·0
Lanthanum	La	138·5
Lead	Pb	206·92
Lithium	Li	7 03
Magnesium	Mg	24·36
Manganese	Mn	55·02
Mercury	Hg	200·0
Molybdenum	Mo	96·0
Neodymium	Nd	143·6
Nickel	Ni	58·70
Niobium	Nb = Cb	94·0
Nitrogen	N	14·045
Osmium	Os	190·8
Oxygen (standard)	O	16·000
Palladium	Pd	106·5
Phosphorus	P	31·0
Platinum	Pt	195·2
Potassium	K	39·140
Praseodymium	Pr	140·5
Rhodium	Rh	103·0
Rubidium	Rb	85·44
Ruthenium	Ru	101·7
Samarium	Sm	150·0
Scandium	Sc	44·0
Selenium	Se	79·0
Silicon	Si	28·4
Silver	Ag	107 93
Sodium	Na	23·050
Strontium	Sr	87·68
Sulphur	S	32·065
Tantalum	Ta	183·0
Tellurium	Te	127·5
Terbium	Tb	160·0
Thallium	Tl	204·15
Thorium	Th	233 0
Thulium	Tu	170·0 ?
Tin	Sn	119·0
Titanium	Ti	48·17
Tungsten	W	184·4
Uranium	U	240·0
Vanadium	V	51·4
Ytterbium	Yb	173·0
Yttrium	Yt	89·0
Zinc	Zn	65·40
Zirconium	Zr	90·5

THE CLASSIFICATION OF THE ELEMENTS.

			K = 39.140	Rb = 85.44	Cs = 132.9	....
			Ca = 40.0	Sr = 87.68	Ba = 137.43	....
			Sc = 44.0	V = 89.0	La = 138.5	....
			Ti = 48.17	Zr = 90.5	Ce = 140.0	..... Th = 233.0
			V = 51.4	Cb(Nb)= 94	.....	Ta = 183.0 .....
			Cr = 52.14	Mo = 96.0	.....	W = 184.4 U = 240.0
			Mn= 55.02	.....	.....	....
			Fe = 56.0	Ru = 101.7	.....	Os = 190.8
			Co = 59.00	Rh = 103.0	.....	Ir = 193.0
			Ni = 58.70	Pd = 106.5	.....	Pt = 195.2
	Li = 7.03	Na = 23.050	Cu = 63.60	Ag = 107.93	.....	Au = 197.3
	Gl = 9.1	Mg = 24.36	Zn = 65.40	Cd = 112.3	.....	Hg = 200.0
	B = 10.95	Al = 27.1	Ga = 70.0	In = 114.0	.....	Tl = 204.15
H = 1.0075	C = 12.001	Si = 28.4	Ge = 72.5	Sn = 119.0	.....	Pb = 206.92
	N = 14.045	P = 31.0	As = 75.0	Sb = 120.0	.....	Bi = 208.0
	O = 16.000	S = 32.065	Se = 79.0	Te = 127.5?	.....	
	F = 19.05	Cl = 35.455	Br = 79.995	I = 126.85	.....	

Unclassified:

Helium	= 2.0 or 4.0 ?	Gadolinium	= 156.0
Argon	= 19.94 or 39.9 ?	Terbium	= 160.0
Praseodymium	= 140.5	Erbium	= 166.0
Neodymium	= 143.6	Thulium	= 170.0
Samarium	= 150.0	Ytterbium	= 173.0

Anomalous:

Cobalt	= 59.00
Nickel	= 58.70
Tellurium	= 127.5

[1] Richards and Parker: Proceedings Am. Acad., 32, 53; Ztschr. anorg. Chem., 13, 81 (1896).

[2] Burton and Vorce: This Journal, 12, 319 (1890).

[3] Richards and Rogers: Proceedings Am. Acad., 28, 200.

[4] Seubert: Ber. d. chem. Ges., 14, 865 (1881).

[5] Halberstadt: Ibid., 17, 2962 (1884).

[6] Clarke: Recalculation (1897), p. 334.

[7] Trans. Roy. Soc. Edinburgh, 33, part II, 561 (1887).

[8] Ber. d. chem. Ges., 21, 2179.

[9] Recalculation, p. 333.

[10] Ann. Chem. (Liebig), 261, 262.

[11] Compare Hardin: Jour. Am. Chem. Soc., 19, 657 (1897).

[1] Smithson. Misc. Coll., Constants of Nature, 5 (1897.)

[2] Bongartz: Ber. d. chem. Ges., 16, 1942 (1883).

[3] Cooke: Proc. Am. Acad., 5, 13 (1877).

[4] Schneider: Pogg. Ann., 99, 293 (1856); Jour. prakt. Chem. (2), 22, 131 (1880).

[5] Dumas: Ann. Chem. (Liebig), 113, 27 (1860).

[6] See Proceedings Am. Acad., 30, 371. Cases in point: Barium, strontium, sodium, and tin.

[7] Von Hauer: Jour. prakt. Chem., 72, 350 (1857).

[8] Partridge: Am. Jour. Sci. (3), 40, 377 (1890).

[9] J. E. Bucher: Johns Hopkins Inaug. Dissertation, Baltimore (1892).

[10] Baubigny: Compt. rend., 97, 906, 951, 1389 (1883).

[11] Marignac: See under magnesium, later in this paper. Compare Proceedings Am. Acad., 25, 260, 273; 31, 160.

[12] Lenssen: Jour. prakt. Chem., 79, 281 (1860).

[13] Morse and Jones: This Journal, 14, 260.

[14] Lorimer and Smith: Ztschr. anorg. Chem., 1, 364.

[15] Proceedings Am. Acad. (1881), p. 28.

[16] Hardin: Jour. Am. Chem. Soc., 18, 1016 (1896).

[17] Erdmann and Marchand: Jour. prakt. Chem., 50, 237 (1850).

[18] Marignac: Arch. Sci. Phys. et Nat. (3), 16, 206.

osmium, palladium, praseodymium, samarium, scandium, thorium, ytterbium, and zirconium. This is by no means a complete list of the uncertain elements, but only of those for which the data admit of slightly different interpretations.

It is rather unfortunate that most classified tables of the elements omit the fractional parts of the atomic weights, for these fractions will undoubtedly play an essential part in the ultimate solution of the De Chancourtois-Newlands-Mendeléeff-Meyer mystery. In order to present a modern table which will supply these omissions, as well as afford at a glance an approximate idea of the probable error in each case, I have repeated the values in the natural order. From the classified table have been omitted several elements whose atomic weights and properties are uncertain: their presence in the system serves rather to obscure well known relations than to elucidate new ones. That this procedure is an admission of incompleteness is evident; the last part of the table is at best a lame affair. The form proposed by Thomsen* is perhaps the most generally satisfactory of the current modes of arrangements, but his last row is unwieldy both for printing and for thinking. In the accompanying table a compromise has been adopted which cannot fail to be comprehensible; it is not my purpose here to enter into the arguments regarding the adequacy of the various forms.

This table will be reprinted, with any changes which may be necessary, every year. Since the commencement of the work I have been glad to hear of the appointment of a committee by the German Chemical Society to accomplish a similar purpose, the American Chemical Society having for several years possessed such a committee. The matter cannot receive too much intelligent examination.

PRESENT STATUS OF ELECTRICAL ENGINEERING.†

WHILE mechanical engineering may be said to have an antiquity coeval with civilization, its latest offshoot, electrical engineering, only came into existence with the advent of the electric telegraph some 60 years ago. For the greater part of this time electrical development was confined to the telegraphic industry; but with the extended introduction of the arc and incandescent lamps, the utilization of the magnetic properties of iron and steel made rapid progress in dynamo construction, so that the magnetic properties of steel now play almost as important a part in the advance of civilization as do its mechanical properties.

By far the greater proportion of electrical development has come within the last decade and a half. Looking back from the Trans-Mississippi Exposition at Omaha of to-day to the International Electrical Exhibition of Philadelphia in 1884, the birthplace of the American Institute of Electrical Engineers, it is doubtful whether outside of telegraphy and telephony there was at that time in the United States a total investment of $1,000,000 in electrical applications. The words ammeter and voltmeter were just commencing to be generally recognized, and of electric traction there was none. At the present time the capitalization in electrical applications in the United States is estimated at about $1,900,000,000.

In 1884 a 50-k. w. dynamo was considered a large machine, while a 100-k. w. Edison steam dynamo was justly called a "Jumbo." At the present time the largest size generator built or building is of 4,600-k. w. capacity. The price of dynamos in 1882 was about 20 cents per watt of output, while dynamos of similar running speed in comparatively small sizes without switchboards now cost about 2 cents per watt. The great reduction in price represents the aggregated result of the very large amount of labor devoted to this branch of engineering in the last fifteen years.

It is interesting to notice that the efficiencies of continuous-current dynamos have not made any marked nominal advance since the birth of the Institute, though their output per unit of mass has considerably increased. Thus the 50-k. w. dynamo tested at the Philadelphia Exhibition is stated to have had an efficiency of approximately 92 per cent., and this would be considered a satisfactory performance in that size of machine to-day. But, where the output then was only six watts per pound of net weight, the output of a machine of similar rating and speed to-day would be about 10 watts per pound. In other words, the efficiencies of the best dynamos of 1884 were already so good that it has not paid, at existing costs of power, to markedly improve them, and such improvements in material and design as have since been effected have enabled manufacturers to increase the rating or yield, and, therefore, the cheapness of the machines. It seems probable, moreover, that this will continue to be the direction of future progress. We scarcely can desire more efficient machines than the best we have now, but we shall always desire cheaper and more powerful machines, and shall welcome any improvements which lead to them.

Another evidence of the development in dynamo machinery is their improved appearance. Formerly the only claim possessed by such apparatus was utility. More recently, grace, the expression of unconscious power, has supervened, and the modern dynamo is often pleasing to look upon as well as useful to operate.

The cost of generating a kilowatt-hour of electric energy from steam for electric lighting appears to have been at least 7·5 cents at bus-bars in 1884. At the present time the cost of delivering a kilowatt-hour to large street railway systems from steam is only about one cent, and the power house operating costs are reported in some cases as low as half a cent. In municipal electric-lighting systems supplied at low pressure from steam central stations and hampered by relatively heavy distributing expenses, the retail price of the kilowatt-hour varies from 20 to about 4½ cents, according to the locality and quantity consumed. Niagara power is now sold to consumers in Buffalo at rates varying, according to the amount delivered, from 2 cents to slightly less than ⅗ of a cent per kilowatt hour delivered.

The price of a 16-candle-power incandescent lamp sixteen years ago was about $1. Now it is about 18 cents.

The best lamps at that time, under laboratory conditions, gave about 0·28 mean horizontal normal British candle power per watt, and under commercial conditions about 0·20. The highest pressure for which they could then be obtained was about 110 volts. At the present time lamps are obtainable giving normally 0·4 mean horizontal British candles per watt, while under commercial conditions the average lamp normally develops about 0·25 candle per watt. They can also be obtained (at 0·25 candle per watt) for pressures up to 240 volts, and are frequently installed on 220-volt mains.

Arc lamps were already so far advanced in 1884 that comparatively little improvement in their effectiveness has taken place, the gain having been made in economy of operation. Thus, the carbons which cost at that time about 6 cents apiece now cost about 2 cents apiece. The inclosed arc lamp has of recent years become popular owing to its diffused light and a carbon life of from 100 to 150 hours.

It has been estimated that about $600,000,000 has been invested up to the present time in electric lighting stations and plants in the United States.

The best storage cells tested at the Philadelphia Exhibition of 1884 gave a yield under laboratory conditions of 3·425 watt hours per pound of electrodes with an energy efficiency of 69·45 per cent. when discharged at the mean current density of 12·42 amperes per square foot of negative plate surface; while the deterioration was comparatively rapid. At the present time storage cells are in use giving under laboratory conditions a yield of from 5 to 6 watt-hours per pound of charged cell (11·0 to 13·23 watt-hours per kilo), with an energy efficiency of about 85 per cent. when discharged at a current density of 4·8 amperes per square foot of negative plate surface. There are now storage batteries installed in the United States to the aggregate capacity of about 56,000 kilowatt-hours. The largest installation has 166 cells, weighs 500 short tons and has an eight hour discharge capacity of 22,400 ampere hours, or 3,136 kilowatt hours at 140 volts pressure.

A very great development has taken place in the direction of electric traction, by virtue of which the horse car, once so well nigh ubiquitous in the city streets, has almost entirely disappeared, while electric locomotives of 1,500 horse power have even made their appearance on steam railroad tracks. The introduction of soft cast steel has been very advantageous to the electric motor, enabling its output to be increased from 5 watts per pound of net weight in 1884 to about 14 watts per pound in street-car motors, at the present time. It is estimated that there are, to-day, in the United States, about 14,000 miles of electric railroad, with a nominal capital of about one billion dollars, and employing about 170,000 men.

The electric transmission of the power of falling water is a branch of engineering that has come into service since 1884, and is making rapid strides, owing to the recent successful employment of high voltages and multi-phase alternating currents. It has been estimated that about 150,000 kilowatts of this class of machinery is installed in the North American continent, commercially transmitting power to various distances up to 85 miles, at various pressures up to 40,000 volts.

The alternating-current induction motor has become very popular in recent years, mainly owing to its powerful starting torque and its freedom from commutator and brushes. A burned-out armature, the perpetual source of dread in motor operations of days gone by, is practically unknown in this type of machine, even when put to severe service. Indeed, its depreciation under fair conditions appears to be as low as in any class of rotating machinery.

The alternating-current transformer has been correspondingly improved, developing in large sizes an efficiency of about 98·5 per cent. and an output, when cooled by external power, of about 100 watts per pound of weight.

The principal engineering value of electricity to-day lies in its adaptation to the transmission of power, through mills or cities, or from some locality where power is cheap to another where it is dear. A steel rope, by its bodily motion, can transmit, with appreciable friction and depreciation, some hundreds of kilowatts to a distance of some thousands of feet. A bare quiescent copper rope, half an inch in diameter, and supported on poles, can, by maintaining an effective potential of 10,000 volts by the motion of electric waves over its surface, transmit say 2,500 kilowatts with an energy loss of two-thirds of one per cent. per mile (0·4 per cent. per kilometer), and with practically no depreciation except to the poles and supports.

The use of high pressure has thus become more frequent during the last few years. Alternating-current generators are now made to supply 10,000 volts at their terminals, and insulation testing sets have been made for producing alternating pressures up to 100,000 volts effective.

The application of electric power to domestic use and household comforts, irrespective of illumination, has made steady progress. In the large cities, the fan-motor day load of summer is in the aggregate a perceptible quantity, while electric ranges and heaters on a small scale have found favor through their convenience.

In telegraphy comparatively little change has recently taken place beyond the substitution of the dynamo or dynamotor for the voltaic battery, and of copper line-wire with some 5 ohms per mile for iron wire with some 13 ohms per mile. About one million miles of telegraph wire are now strung on some 200,000 miles of pole line in the United States, connecting about 25,000 offices and working a capitalization of about one hundred and fifty millions of dollars.

In the United States the uniformity of the closed circuit Morse system, simplex, duplex, or quadruplex, is only varied by an occasional Wheatstone set. The crystallization of methods is not due to any lack of invention or capability of improvement in signaling speed, but rather to the apparently settled belief that the present systems are the most economical under existing conditions of traffic. In long submarine telegraphy the pressure of increasing traffic has made itself more distinctly felt, and automatic curb-senders have, to some extent, been introduced, but the physical difficulties in the way of attaining high speeds have as yet been obviated only in part by an increased expenditure in copper and gutta-percha, to obtain a diminished conductor resistance per mile. Wireless telegraphy has entered its experimental stage, and bids fair to enter practical service in the future, at least within a limited range. Its public use thus far in the United States seems to have been limited to blowing up at stated intervals, in the recent New York Exhibition, miniature models of the "Maine," at a distance of some 25 meters from the oscillator.

In telephony, the most notable improvement in recent years has been the general substitution of metallic circuits for ground return circuits, with great advantage to the convenience and effectiveness of the traffic. At the present time conversation is carried on commercially up to a distance of 1,800 miles, and quite frequently at distances of 1,500 miles. There are at the present time in the United States about 1,000,000 telephones connected with the telephone service of the country, employing a capitalization of about $100,000,000 with 400,000 stations and about 900,000 miles of wire. Every day about 17,000 employés make on an average more than 3,000,000 of connections. About 300,000 miles, or nearly one-third of the total length of telephone wires, have, within the last few years, been made up into aerial and subterranean cables within city limits, owing to the reduction of the electrostatic capacity effected in such cabled wires to less than one-twelfth of a microfarad per mile of single wire.

At no time has a useful discovery or improvement had more chance of welcome or application than at present. As an example, the case of Roentgen rays may be cited. Prof. Roentgen's celebrated paper announcing the discovery of X-rays was read in Wurzburg in December, 1895, and the particulars were not known in the United States until early in 1896. In the same year (December, 1896) radiographs were accepted as legal evidence in a United States district court.

A considerable development has occurred in electrothermic and electrolytic processes. More than 4,000 kilowatts of Niagara power are now employed in such processes. Among electro-chemical processes are the electrolytic refining of copper to the extent of about 150,000 tons annually, the production of aluminum, the production of sodium and alkalies, and the treatment of ores. Among electrothermic processes are the production of the carbides of silicon and calcium in steadily increasing quantities.

In electrotechnical theory considerable advance has been made of recent years, particularly in the study of alternating currents. Accompanying the expansion of knowledge in the various branches there is a tendency to combine and unite them into one general theory. Thus, while the early dynamos generated a low-tension electricity which was once regarded as something so dissimilar to high tension electricity as to require separate treatment and classification, to-day the high tensions derived from alternators through step-up transformers so far invade the territory of so-called frictional electricity that a dividing line between the two classes can no longer be maintained. Similarly, telephony and telegraphy are coming to be regarded as subclasses of alternating current power transmission, while electricity and magnetism cannot properly be studied apart.

Although a large amount of electrical work is done in physical laboratories in the United States, a comparatively small amount of the results of this work becomes available to the science or art of electrical engineering. Each year sees more than a hundred students engaged in experimental thesis work after a laborious training and preparation for several years in the technical college. Many of these men have the time and facilities to do the best experimental work of their lives under the guidance of their instructors. Some of the men display aptitude and interest in some special line of research in which they would be best left untrammeled, but in most cases the experimental work under co-operative guidance could accomplish a great deal for the knowledge and progress of our branch of applied science. There are numerous questions concerning the various electromagnetic properties of matter and of the ether that are of great and growing importance, and there are numerous scientific subjects of immediate practical importance that it is necessary to measure and observe, so that by uniting the available experimental resources of the various colleges in this country under a common leadership, in sympathy with the college instructors, the results which now largely fill thesis books lying on neglected shelves might be incorporated into permanent results for the general advancement of our profession. The plan would involve practically no expenditure beyond the voluntary efforts of those upon whom the duty devolved of formulating and dividing the subjects of research, and classifying or comparing the results attained. Such a system of co-operation among the students through their instructors would economize a large amount of the most skilled technical labor, and accelerate progress in all branches of inquiry, application, and industry. No better work could be undertaken by our Institute than the fostering of such an organization.

The technical progress of a profession like ours is shown by the precision of which it is capable. A loose nomenclature begets looseness of observation and description, and is inconsistent with a high degree of development in a science that quickens the footsteps of every human industry. The tendency of our machinery and definitions to become standardized is apparent in the impulse which has led the American Institute of Electrical Engineers to appoint a committee on standardization, the preliminary report of which is to-day laid before this Institute for consideration.

In connection with standardization it is important to observe that there has been of recent years a tendency to depart from the regular standards of dynamo machinery built by the manufacturers, in favor of special machinery of independent design. To a limited extent this is, of course, necessary under the pressure of changing methods and conditions, but there is reason to believe that more special machinery is built than necessity can warrant. Not only is the special machinery thus ordered or specified considerably more costly than standard machinery, but the tendency, by interfering with the natural shop methods of standardizing and cheapening production, prevents regular consumers from purchasing standard machinery at as low rates as would otherwise be possible. When we consider that the industrial radius of application of electricity mainly depends upon the

* Ztschr. anorg. Chem., 9, 190.

† Inaugural address of President A. E. Kennelly before the American Institute of Electrical Engineers.

first cost of the apparatus it employs, it needs no homily to drive home the conviction that the unnecessary introduction of special machinery is a puncture in the tire of progress.

Our Institute may well take pride in the share which it has taken in the electric progress of the 14 years which have elapsed since its inception. It now numbers 1,100 members. Its purpose is to aid all who seek to acquaint themselves with this branch of science and art, and to set the stepping stones of progress in the sands of time for the advance of the industrial applications of electricity.

PORTO RICAN ANTIQUITIES.

THE expedition to Porto Rico, which is to be led by Prof. N. L. Britton, of the New York Botanical Gardens, promises to be productive of the most interesting results. It has for a primary object the collection of rare plants for the Botanical Gardens here, but it also has a secondary object of great interest, and that is the gathering of data concerning the life and customs of the vanished people who occupied the island centuries ago, before the time of Columbus. The Spaniards, when they came into possession of the island, following out their fierce policy of colonial rule, within a few years completely exterminated the aborigines, the number of whom was about one million. They were known to be a quiet race, possessing many arts and industries of a semi-civilized people, yet history has recorded but little about their character and culture. Recently many strange relics have been found on the island, the like of which has not been seen anywhere else in the world. They are supposed to be of a religious significance, and are mainly in the nature of animal and human figures carved out of stone.

In its day Porto Rico was the center of all religious ceremonies and festivals held by the natives living on the widely scattered islands of the Antilles. In rude canoes, sailing-boats and other craft of the time the savages of that wide watery region made yearly pilgrimages to Porto Rico to engage in a sort of Indian camp-meeting. There the civilization and culture of that section and that time were focused.

Up to the present time only one noteworthy collection of relics from that section has been made. George Latimer, formerly a United States consul to Porto Rico, who was of a scientific turn of mind, put in the greater part of his time collecting specimens there, and when he died at his post left everything he had collected to the Smithsonian Institution.

Most of the relics found indicate that the natives of this country were of an intensely religious character.

The great religious amphitheater of ancient Porto Rico, according to facts gleaned, was a large inclosure surrounded by stone walls, and avenues of palm trees led up to it from all sides. In the center of the inclosure was the "holy of holies," where the sacred objects were kept. This inclosure was covered by a palm leaf thatch as a protection against rain. Every tribal chief had a similar place of worship, and this was the great gathering place or conference building. There was a well-established priesthood and a well-regulated system of shrines. Each house, also, in one of its angles, had a shrine. These houses were of great size and sheltered under one roof hundreds and sometimes as many as a thousand persons. Those in the house were all more or less remotely related.

The Latimer collection includes many quaint pieces, some of which are almost impossible of explanation, presenting many problems for the scientists of the outgoing expedition to solve. There are some stone pieces which, for want of a better name, have been termed collars. They look much like horse collars. They are ornamented with carving. It is believed that they were worn by the priests during certain religious ceremonies. There are many conventional axes, carved and polished. There are also stone masks that represent grotesque human faces. Curious also are many stools, made from both wood and stone. These stools are ornamented with pearls and precious stones and are supposed to have been thrones. Stone tables, supported by four short legs, are also in the collection. They are supposed to have been used to grind corn with stone rollers. The aborigines also made some beautiful pottery, a few relics of which remain. All of these things open a delightful vista to the scientists, and those who make up the proposed expedition look forward with keen interest to the work they have before them.—New York Tribune.

THE VALUE OF THE METER IN FEET AND INCHES IN DIFFERENT COUNTRIES.

THE various states of Germany, as well as the other countries of Europe, although having adopted the decimal system of measurement of length, still retain to a large extent their old units of measurement, the foot and inch. The worst part of it is, that the values of these differ not only between nationalities, but between parts of the same nation. The Papier Zeitung has collated, in tabular form, the value of the meter in the more prominent countries of the civilized world, which we present below:

Countries in which the foot and inch are still in use.	Value of one meter in feet.	Inches to the foot.	Centimeters to the foot.	Centimeters to the inch.
Austria	3.163	12	31.61	2.63
Baden	3.333	10	30.00	3.00
Bavaria	3.426	12	29.19	2.43
Denmark	3.186	12	31.39	2.62
Great Britain	3.280	12	30.48	2.54
Hanover	3.426	12	29.19	2.43
North America	3.280	12	30.48	2.54
Norway	3.186	12	31.39	2.62
Prussia	3.186	12	31.39	2.62
Russia	3.280	12	30.48	2.54
Saxony	3.531	12	28.32	2.36
Sweden	3.368	10	29.69	2.97
Switzerland	3.333	10	30.00	3.00
Wurtemburg	3.400	10	29.65	2.96

The Great Eastern Railway Company, of England, is about to build a large hydraulic hoist to connect the East London Railway with its line at Spitalfields coal depot. The platform of this hoist will be 47 feet by 15 feet, and will be capable of lifting two loaded trucks weighing 35 tons. The total height of lift will be 44 feet.

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Steam Boilers. The Heat Efficiency of Steam Boilers: Land, Marine, and Locomotive. With tests and experiments on different types, heating value of fuels, analyses of gases, evaporation, and suggestions for testing boilers. By Bryan Donkin. With numerous tables, plates, and illustrations in the text. 8vo, cloth, 311 pages. London, 1898..... $8 00

Steam Boiler Construction. A Practical Handbook for Engineers, Boilermakers, and Steam Users, containing a large collection of data relating to recent practice in the design, construction, and working of all kinds of Stationary, Locomotive, and Marine Steam Boilers. By W. S. Hutton. Third Edition. London, 1898..... $6 00

Submarine Telegraphs. Their History, Construction, and Working. Founded in part on Wunnschendorff's Traite de Telegraphie Sous-Marine and compiled from Authoritative and Exclusive Sources. By Charles Bright. Large octavo, profusely illustrated, 744 pages. London, 1898..... $25 00

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Telephone. Outlines of the Development of Transmitters and Receivers. By Wm. J. Hopkins. 12mo, cloth, 88 pages, illustrated. New York, 1899..... $1 00

Tool Making. The Practical Tool Maker and Designer: A Treatise upon the Designing of Tools and Fixtures for Machine Tools and Metal Working Machinery, comprising modern examples of machines, with fundamental designs for tools for the actual production of the work; together with special reference to a set of tools for machining the various parts of a bicycle. By Herbert S. Wilson. Illustrated by 189 engravings. 8vo, cloth, 209 pages. Philadelphia, 1898..... $2 50

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